FLIGHT MANAGEMENT COMPUTER

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FLIGHT MANAGEMENT COMPUTER CONVENTIONS AND USAGE

Overview: The Next Generation 737 uses a fully integrated Flight Management System that is comprised of the following core equipment:

- Autopilot Flight Director System
- Flight Control Computers
- Flight Management Computer CDUs
- Autothrottle
- Inertial Reference System
- Navigation Equipment

Together these systems provide a fully automatic, full regime flight control and information display system. The FMS is capable of providing flight control from takeoff to rollout.

There are two primary tools that crewmembers use to interface with the FMS: the Flight Management Computer/Control Display Units (FMC/CDU) and the Autopilot Mode Control Panel (MCP).

The backbone of the FMS is the Flight Management Computer/Control Display Unit. The FMC/CDU performs the following major functions.

- Flight Planning
- Navigation Computation
- Navigation Display
- Guidance Commands (pitch, roll and thrust)
- Interface to Inertial Reference System (IRS)
- Performance Optimization
- Thrust Limit Calculation
- Autothrottle Control

The FMC takes input and sensory information from many aircraft systems, including the following:

- Flight Control Computers (FCCs)
- Air Data Computer
- Fuel Quantity Indicating System
- Weight and Balance Computer
- VOR/DME/ILS Receivers
- Inertial Reference System
- Digital Clock
- Mode Control Panel
- FMC Database
- FMC/CDU (Crew inputs)

Input from these systems is combined to conduct comprehensive aircraft control calculations. Output from the FMC/CDU is sent to the following systems:

- Integrated Display System (PFD & ND)
- Autopilot Flight Director System
- Mode Control Panel
- Autothrottle Servo
  - Electronic Engine Controls

Launching the FMC/CDU: The Next Generation 737 cockpit has two FMC/CDUs mounted at the forward end of the throttle pedestal.

To closely model the functionality of the 737 Next Generation cockpit, the PMDG 737 is capable of displaying two FMC/CDUs on the screen at one time.

To activate the captain's FMC/CDU, press the "F" key on the panel switch device:

The second FMC/CDU can be activated on screen by selecting it from the VIEWS/PANELS menu within Microsoft Flight Simulator.

Both FMC/CDUs can be operated from within the Virtual Cockpit as well.

Each FMC/CDU is linked to it's own Flight Management Computer mounted in the aircraft's electronics bay. Each FMC is comprised of five processors, and integrates data received from the air data sensors, crew input, navigation radios, engine and fuel sensory systems, inertial reference system and internal navigation database. This information is then used to provide steering commands to the autoflight systems in both roll and pitch modes, as well as to the autothrottle servos. Navigation and positional data is provided to the Navigation Display.

Each FMC is capable of receiving input independent of the other, and both systems will continually compare input/process results to ensure information consistency on both FMCs. If inconsistencies are detected, a resynchronization process is automatically initiated.

FMC/CDU Layout: The FMC/CDU is comprised of a data display screen with six line select keys located on the left and right sides of the screen respectively. The data display screen is capable of showing 14 lines of data 24 characters wide in both large and small fonts. Numeric and Alphabetic keys are provided for crew input. Fifteen function and mode keys are provided to assist the crew in selecting and managing FMC modes.

FMC/CDU Display: The MCDU display screen is comprised of 14 data lines capable of displaying 24 characters across in large or small font.

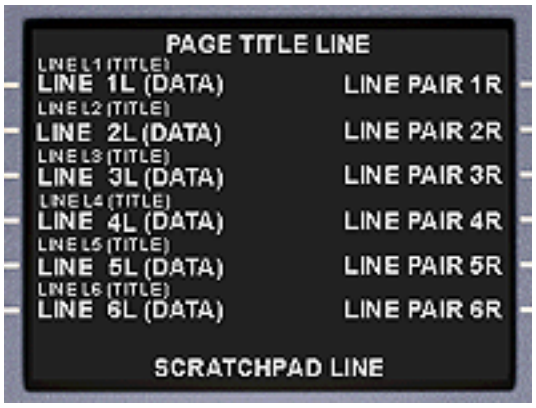
The display is broken into three distinct areas:

- Page Title Line
- Text Lines (1-6)
- Scratch Pad

The title line is present on every page and describes the current page that is being viewed along with that page's data status. (ACTive, MODified, etc.)

The text lines contain information that is aligned against the left and right sides of the display, and can be manipulated by the Line Select Keys.

The Scratchpad is where crew data entry will take place. All entries that are made by the crew for entry into the FMC must first be entered into the scratch pad.



Title Line: Top line of the display. Shows title of current page display. You can use this line to tell immediately what page of the FMC you have displayed.

Line Select Keys: The FMC/CDU has six LSKs on each side of the screen in order to facilitate data input and manipulation. The keys are identified by their position relative to the display and their sequence from top to bottom. (e.g. The LSKs are identified as either Left or Right and are numbered from 1 to 6 starting at the top.)

The LSKs are used for the following functions:

- Down-selection of data from a particular line to the scratchpad (if the scratchpad is empty.)
- Data Entry from scratchpad into selected line.
- Access to data or function identified by LSK.

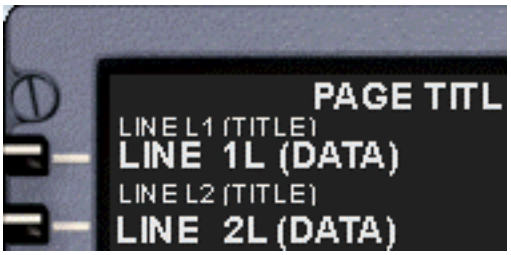
To down-select information into the scratch pad, simply press the LSK next to the data you desire to copy. This will cause the information to be copied to the scratch pad line.

To up-select information from the scratch pad to a line in the display, simply press the LSK for the line to which the information is targeted. This will cause the information to be copied from the scratch pad to the desired line in the display.

(Obviously, some information cannot be down/up-selected. Most lines that require information input from the crew will accept down/up selection of information, however.)

Scratchpad: The last line of the display is a scratchpad which allows for alpha numeric input by the crew, or down-selection of FMC data from other lines.

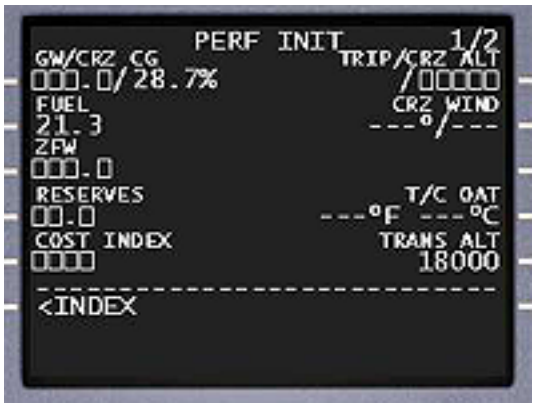
Data Lines: Six pairs of lines that contain data and information. Lines may also contain prompts for data input by the crew. The upper line in each line pair is called the Title Line (small font), while the lower line is called the Data Line (large font). Lines and line pairs are referenced by the associated LSK on either side of the display. (Hence 1L, 2L, 3L or 1R, 2R, 3R, etc.)



Display Norms and Prompts: The FMC/CDU has certain norms that, if recognized, make the unit easier to use.

Required Entry Boxes: In order to operate, the FMC requires certain information to be entered. Gross Weight, Fuel Reserves and Cruising Altitude are examples of information that the FMC needs in order to operate correctly.

Boxes in any FMC/CDU display line indicate that information is required by the FMC. Examples include Gross Weight, Startup Position, etc.



LSK Prompts: At any time a '<' or a '>' carat is used adjacent to a line select key, this indicates that an additional or related menu can be accesd by pressing the associated LSK. For example, the <INDEX prompt above indicates that pressing the 6L LSK will take you to the INDEX page.

Crew Data Entry/Selection Lines: Dashed lines allow for crew entry of specific data which is unique to each individual flight, such as departure airport, destination airport, speed/altitude restrictions, flap acceleration heights, etc.

Page Numbers: Many pages of information contain more information that the FMC/CDU screen is able to show at one time. In these cases, the FMC/CDU will display a page counter at the upper right corner of the screen. (In this case, 1/3 indicates that the display is currently showing screen one of three total screens for POS IDENT.

Using the CLR key: Pressing the CLR key a single time is similar to pressing the backspace key on a conventional keyboard. In order to facilitate erasing the scratch pad, we have added the ability to press and hold the CLR key to delete the entire contents of the scratch pad. To remove all items in the scratchpad, simply press and hold the CLR key for one second.

FMC DISPLAY PAGES ACCESSED WITH MODE KEYS

Overview: The PMDG 737: The Next Generation uses an FMC that has fifteen mode keys available on the FMC/CDU. These keys provide direct access to a number of functions within the FMC that will be used by the crew during various phases of flight.

MENU Key: The MENU key provides access to the FMC and other aircraft sub-systems that use the FMC/CDU for input or control. When pressed, the MENU key brings up the following display screen on the FMC/CDU:

In the current version of the PMDG FMC, not all functions are active from this screen, as evidenced by the *grayed out* items in the menu. Currently only the FMC function is available by the FMC/CDU, but ACARS functionality is planned.

If pressed during flight, the <FMC prompt will bring up the last displayed FMC page. When the MENU page is active, a <STATUS> prompt will be shown adjacent to each FMC/CDU function.

<ACT> Indicates that the sub-system is currently active and operating.

<HLD> Indicates that the pilot has selected the sub-system but the FMC/CDU has not yet established active communications with that sub-system. (In this case because ACARS functionality is not currently available in the PMDG FMC.)

INIT REF Key: When pressed, the INIT REF key will provide access to one of the following pages:

- IDENT
- POS
- PERF
- THRUST LIM
- TAKEOFF
- APPROACH

The FMC will automatically display the page which is most appropriate for the current phase of flight. During the preflight phase, for example, the FMC will begin by displaying the IDENT or POS pages so as to allow the crew to begin initializing the FMC.

During the approach phase of flight, the FMC will automatically choose the APPROACH page, etc.

If the page displayed is not the page desired by the crew, pressing the LSK which has the <INDEX prompt (usually 6L) will return the MCDU to the following screen:

The INIT/REF INDEX page allows crew access to the following initialization and reference pages:

- IDENT: Aircraft identification and nav database verification page.
- POS: Position Initialization (on ground) or Position Reference page (in flight).
- PERF: (Located on page 2/2 of PERF page) Performance initialization page (Gross weight, Fuel Loading, Cost Index, etc.)

- TAKEOFF: Takeoff parameter reference and initialization page.
- APPROACH: Approach reference and initialization page.
- NAVDATA: Display and list navdata information and saved flight plans.

Other functions listed on this page are not implemented, but are included here for completeness and growth of future functionality.

If the INIT/REF INDEX is reached via the MENU key, the following menu will be presented. *(Grayed out items are not yet implemented.)*

RTE Key: When pressed, the RTE key provides access to the ROUTE page. The ROUTE page will be blank if a new route has not yet been loaded, or it will display ACT RTE (route is activated) or MOD RTE (route has been modified and needs confirmation.)

The route being displayed is described by the title line of the RTE display, and can be any of the following:

RTE or ACT RTE or MOD RTE
- Route 1 was displayed.
- Route 1 is active.
- No route was activated.

Note: *Currently the PMDG FMC is only capable of displaying a single route entry. The actual aircraft allows two.*

The RTE page displays the waypoint fixes and the method that the FMC will use to reach each successive fix. (Jey Route, Victor Airway, Direct, etc.)

CLB Key: The CLB key is used to display the FMC/CDU page dedicated to climb thrust and altitude control.

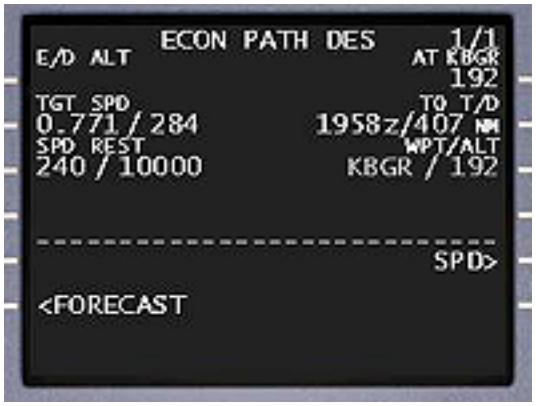
The CLB page is used to monitor the progress and performance of the climb, as well as to set the desired performance or adjust the speed of the climb.

CRZ Key: The CRZ key is used to monitor and adjust the parameters that are being used to manage flight during cruise.

The CRZ page provides information related to altitude, fuel and speed that can be used by the crew to plan and manage decisions effectively.

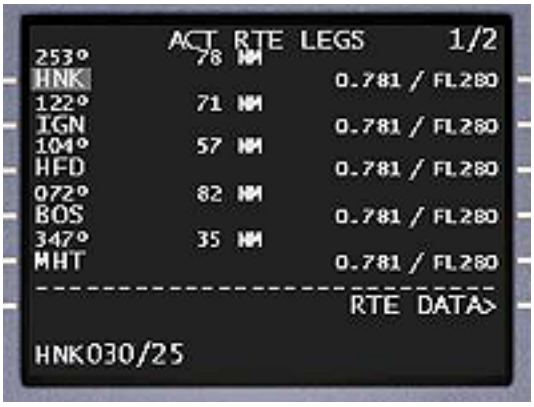
DES Key: The DES page provides descent speed, fuel and planning information that can be used to control the descent portion of flight.

There are two methods used to calculate the descent phase of flight, and the active method is displayed as part of the DES page title.



LEGS Page: The LEGS page is similar in function to the RTE page in that it displays the loaded route of flight. The LEGS page differs, however in that the LEGS page will show every single fix over which the flight will cross, while the RTE page only shows the major route fixes that connect the individual navigation methods to make up the route.

The LEGS page is used frequently during the course of flight to manage altitude and speed constraints Additionally the legs page is used to modify individual fixes along the route of flight, or to enter customer waypoints into the flight plan.



DEP/ARR Key: The DEP/ARR key accesses the DEPARTURES and ARRIVALS pages and the DEP/ARR INDEX page. These pages are used to select published departure procedures (Standard Instrument Departures, or SIDs) and published terminal arrival procedures, (Standard Terminal Arrivals, or STARs).

The DEP/ARR INDEX page allows the crew to select (using the appropriate LSKs) either the appropriate DEP procedure, or an ARR procedure for either of the two possible routes stored in the FMC

HOLD: The hold key provides control pages through which the crew can establsih and control the addition of holding procedures to the active flight plan.

PROG Page: The PROGRESS page is used to monitor the progress of flight and parameters such as time, distance and fuel consumption.

EXEC Key: The EXEC key is only active when the light bar contained within the key is illuminated. The key is used to confirm and changes to the vertical and lateral route plan.

At any time the EXEC key is active, an <ERASE prompt will appear on the MCDU display in order to facilitate cancellation or deletion of a proposed action.

N1 LIM Key: The N1 LIMIT page allows for the selection and control of engine performance limits during takeoff, climb, cruise and descent.

FIX Key: The FIX page allows the crew to enter desired visual waypoints onto the Navigation display by defining them in relation to known points within the Navaid database.

The fixes are no required to be a part of the active flight plan, and are displayed as green information on the display.

NEXT PAGE/PREV PAGE Keys: The NEXT PAGE and PREV PAGE keys are used in conjunction with MCDU displays which occupy more than one page on the MCDU display. Multiple page MCDU displays are indicated by the use of page numbering in the upper right hand corner of the MCDU display.

A wrap around feature is included so that if the NEXT PAGE key is pressed again when the current page is the last in the display, (e.g. 5/5) then the first page of the display (1/5) will be displayed next. This feature also works for the PREV PAGE key

FLIGHT MANAGEMENT SYSTEM INTERNAL FUNCTIONS

Performance Management: The FMS is capable of managing nearly all aspects of aircraft performance so as to optimize precision and economy of flight. The FMS is only capable of providing such information if the gross weight, cost index target altitude and a route have been entered into the FMC/CDU by the crew.. Vertical Navigation can only be accomplished if the performance initialization page is complete.

The performance model uses input from fuel flow, engine data, altitude, gross weight of the aircraft, flaps, airspeed, Mach, temperature, vertical speed, acceleration and location within a programmed flight plan to determine the optimum performance for the aircraft at any given moment.

The performance management modeling used by the FMS attempts to provide a least cost performance solution for all phases of flight, including climb, cruise and descent. The default cruise performance management setting is ECON, or economy cruise.

The airplane and engine data models are used to provide an optimum vertical profile for the selected performance mode, even if ECON has been overridden by the crew. During the climb, an optimum Mach speed target and a corresponding thrust target are computed by the FMS, with the speed target transmitted to the vertical guidance function of the autoflight director system. The AFDS will then generate commands to the elevator in order to maintain the correct pitch for the required speed. Thrust setting commands are delivered to the autothrottle servos by the FMS, and used in conjunction with the pitch setting commands to maintain the optimum speed and climb as directed by the FMS.

During cruise, an optimum Mach setting is computed and thrust setting commands are delivered to the autothrottle.

During descent, a vertical path is computed based on the flight plan entered into the FMC/CDU. The FMS will evaluate expected wind conditions, aircraft speed, altitude, position relative to the planned end-of-descent point and any intermediate altitude or speed constraints between the aircraft and the end-of-descent point. This information will be passed to the AFDS for pitch based speed and vertical speed control and the autothrottles for vertical speed and thrust management. In ideal conditions, an idle thrust optimum descent profile is flown, however in many cases thrust and pitch will be varied to account for wind conditions or to ensure proper tracking of the vertical descent profile.

Important Note Regarding MSFS: *It should be noted that the PMDG FMC uses realistic algorithms to compute the effect of wind conditions and reported wind conditions on the planned descent profile. Some weaknesses in the modeling of weather transitions within MSFS may cause rapid shifts in reported wind-speed and direction, which may have the effect of changing the predicted descent path.*

For this reason, PMDG does not recommend using this airplane with any third party weather generation software, as we have found large variances in manner in which these software packages attempt to manage sudden wind shifts within MSFS, thus causing unreliable descent angle and wind effect prediction.

Navigation Accuracy: The FMS automatically selects and tunes VHR Omni-Range (VOR) and Distance Measuring Equipment (DME) in order to constantly update the position and speed of the aircraft. This information is used in conjunction with the Inertial Reference System (IRS) and Global Positioning System (GPS) to ensure accuracy in all phases of flight.

The FMS will primarily attempt to GPS position information, then combine range information corrected for slant range from two separate DME locations, and finally position from three Inertial Reference Units (IRUs). If no usable VOR/DME information is available, the FMS will monitor aircraft position based on IRS/GPS data only, until the aircraft is determined to be in a location where DME/VOR information is once again

available for position and velocity cross checking.

The FMS navigation management system will also compute and provide true and magnetic track information, drift angle, magnetic variation for the current aircraft location and vertical flight path information.

The FMC automatically determines which VOR/DME combinations will yield the best result given their position relative to the aircraft.

Guidance Management: Two dimensional flight path management is available along an FMC programmed flight path in either the vertical navigation mode (VNAV) or lateral navigation mode (LNAV). Both of these modes are selected by using the LNAV/VNAV buttons on the Autopilot Mode Control Panel (MCP). When used in conjunction with one another, the FMS is capable of providing fully integrated three dimensional flight path management along the FMC defined flight path.

The LNAV guidance function issues steering commands to the AFDS in order to keep the aircraft navigating correctly along the programmed route of flight. Deviations from the center of the desired flight track are corrected using intercept procedures and flight track adjustments. Normal lateral flight path deviation should not exceed 0.1nm in most phases of flight.

In all phases of an LNAV managed flight, the FMS will monitor cross track error, which is defined as the lateral distance separating the aircraft from it's desired path of flight. Roll and steering commands are provided to the AFDS Flight Control Computers in order to correct the cross track error.

The FMS is capable of providing a great circle Direct-To track to any point programmed into the FMC/CDU displayed flight path.

The VNAV guidance function controls the aircraft along the vertical flight path as defined by the FMC/CDU entered flight path and the aircraft's performance limitations.

VNAV takes position data from the navigation system and compares it to the vertical profile as defined in the FMC/CDU entered flight plan. The vertical navigation function then provides pitch and thrust commands to the AFDS in order to intercept and maintain the defined vertical profile for the current phase of flight.

For vertical performance modes where vertical speed is unconstrained (most climbs) the VNAV system will provide pitch and thrust commands to the AFDS so as to maintain the most efficient climb based on the current thrust mode selected. This results in the most economically beneficial climb gradient, not necessarily the most rapid climb gradient.

VNAV uses essentially two basic pitch control modes to manage the vertical flight profile: speed or rate of climb/descent.

When speed the controlled factor the AFDS autothrottle will be given a target thrust setting by the vertical navigation function, and the elevator will be used to control speed, resulting in a variable rate of climb or descent based upon conditions.

When vertical speed is the controlled factor, the AFDS will issue commands to the elevator for vertical speed control, and the AFDS will adjust the autothrottle to maintain speed, resulting in a fixed rate of climb/descent and variable speed based upon conditions.

Thrust Management: The FMS thrust management function is capable of performing autothrottle control law calculations based upon commands from the navigation function, as well as direct crew input from the FMC, manual adjustment of throttle position, or AFDS autothrottle commands.

The autothrottle control law function provides automatic N1 equalization in all modes of flight, as well as thrust limit protection and N1 thrust requirement calculations to maintain MCP or AFDS speed and thrust settings.

Autothrottle modes can be selected or overridden by the crew as required.

PRE-FLIGHT INITIALIZATION PROCESS

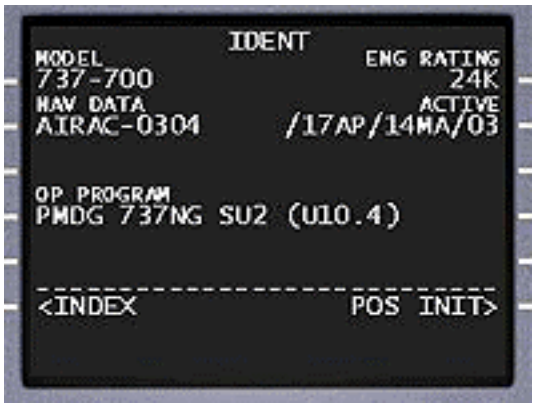
Overview: When power is first applied to the aircraft, the FMC/CDU conducts a full self test and is then ready for preflight initialization. The preflight portion of FMC operation prepares the flight management system with information that is needed in order to manage flight.

Note: *Tremendous effort has been placed into the development of a high fidelity FMC/CDU interface, AFDS, MCP and predictive algorithms for flight planning and conduct.*

An FMC is not simply a sophisticated GPS, but should be viewed as a highly sophisticated scientific instrument. The complexity of mathematics contained in real FMCs has been reproduced here to an extensive degree using actual engineering methods and principles.

In some cases we have not included certain functions within the FMC/CDU as they were not deemed to be reasonably usable within the confines of MSFS. As we continue development of the airplane and it's systems, some new functions will of course b added. Please keep your PMDG 737 up to date by ensuring you always have the most current Service Updates installed!

IDENT Page: When first powered, the FMC will display the IDENT page.



The IDENT page is easily identified by the IDENT title page line at the top of the display screen.

Helpful Hint: *Pay close attention to the information that appears in the TITLE LINE of the FMC/CDU screen. You will find that the pages are intuitively named, and learning the name of pages with specific information will help you quickly master the sophisticated FMC/CDU!*

The data displayed on the IDENT page identifies the aircraft by type, engine thrust rating, navdata cycle FMC Operating Program.

The data appearing on this page should not change on a regular basis, but it is important that this preflight check be accomplished in order to protect against system faults or improper system reloads during updates and/or changes to the FMS or FMC navdata information.

The following information is provided on the IDENT page:

MODEL: The airplane model is displayed in line 1L.

ENG RATING: The thrust rating of the engines current installed is displayed in line 1R.

NAV DATA: The current navdada cycle and effective dates are displayed.

PMDG has selected Richard Stefan's venerable AIRAC navdata cycle database system to power the PMDG FMC. This decision was made based on the wide acceptance of this navdata system within the simulation community, and the dedication and accuracy of Richard Steffan's work. The navdata cycle information is displayed in the NAV DATA line, and the active dates for the database are displayed under the ACTIVE title on the right side of the screen.

Helpful Hint: *If you see the phrase INSTALLATION REQUIRED under the NAV DATA title, this means that you do not have the AIRAC navdata information properly installed, and your FMC/CDU will not operate correctly!*

To install the navdata information correctly:

1) Got to www.navdata.at

2) Download and install the 767PIC/PMDG All-In-One installer

3) Install the navdata into the following directory:

FlightSimulator/FMCWP/NAVDATA

(replace FlightSimulator with the location of your FS installation!)

4) Download the SID/STAR database from our 737 Operators Information Center

5) Place all the SID/STAR files into the FS/PMDG/SIDSTARS directory.

Now you will have access to the full range of navdata and sid/star information for the FMC/CDU!

OP PROGRAM: The operational program identifier is displayed in line 4L. This number is the part number of the FMC operational software program. If this number is not matched identically by both FMCs, then the system will remain locked at the IDENT page. (Call Maintenance! You cannot fix this from the airplane!)

Toward the bottom of the screen, Line 6 contains two prompts, <INDEX (on the left) and POS INIT> (on the right.)

Pressing the 6L LSK adjacent to the <INDEX prompt will display the INIT REF INDEX page. Pressing the 6R LSK adjacent to the POS INIT> prompt will display the Position Initialization page of the FMC.

POS INIT Page: The POS INIT page allows for position initialization of the Inertial Reference System (IRS). In the current version of the PMDG FMC, the IRS is not currently modeled however, the information is provided below in anticipation of the IRS position update capability being added at a later date.

The POS INIT page is selected by pressing LSK at the POS INIT> prompt, or by selecting <POS INIT from the INIT/REF INDEX page.

The fields displayed on the POS INIT page are as follows:

LAST POS: This reference position is the last recorded position of the aircraft at the time the aircraft was powered down, or at the time the brakes were last set. If determined to be applicable, this information can be down-selected via the scratchpad to satisfy the position initialization requirements of line 4R.

Crews are advised to use caution when down-selecting the LAST POS reference position, as it may contain accumulated IRS drift inaccuracy from the previous flight. In addition, if the aircraft has been towed to a new gate or moved while the IRS was not aligned, the reference position will be inaccurate.

REF AIRPORT: Entry of a reference airport ICAO code (International Civil Aviation Organization) will cause a reference position to become available in 2R. This reference position can be down-selected via the scratchpad to satisfy the position needs of 4R if desired.

GATE: The gate position reference is not currently modeled in the AIRAC database but is used to provide exact gate position

reference to the IRS during position initialization.

SET IRS POS: The prompt boxes at 4R indicate that current aircraft position has not be initialized, or that any of the IRS modules is in the align mode. (If neither of these conditions is true, then 4R will be blank.)

To satisfy the prompt boxes at line 4R, the reference latitude/longitude position can be entered directly into the scratch pad, then line selected to 4R, or by -selection of the LAST POS or REF AIRPORT reference position via the scratch pad.

Helpful Hint!: The IRS is not currently modeled in the PMDG 737. As such, it is not necessary to pass the current airplane location to the FMC via the POS/INIT page of the FMC. Once the PMDG 737 IRS is installed, this function will become necessary.

GMT MON/DAY: Line 5L displays the current time in GMT according to the airplane's clock.

RTE Page: The RTE page is used to program the route to be followed during flight. On this page information such as origin, destination, company route name (for saved flight plans) flight number and planned departure runway can be added.

The RTE page is accessed either by pressing the RTE key on the FMC/CDU or by selecting the ROUTE> prompt from the POS INIT page.

The fields displayed on the RTE page are as follows:

ORIGIN: The airport of origin for the flight. Valid entries include any four letter ICAO airport code. Type the desired entry into the scratch pad using the FMC keyboard, then upselect to the ORIGIN by pressing the 1L LSK. (Note that the boxes indicate that origin and destination are required entries!)

DEST: Airport of destination. Valid entries include any four letter ICAO airport code.

CO ROUTE: To load a previously saved flight plan into the FMC/CDU, simply type the name of the saved flight plan into the scratch pad and upload it to the 2L LSK.

Helpful Hint!: Saving and loading flight plans is covered in greater detail on page __

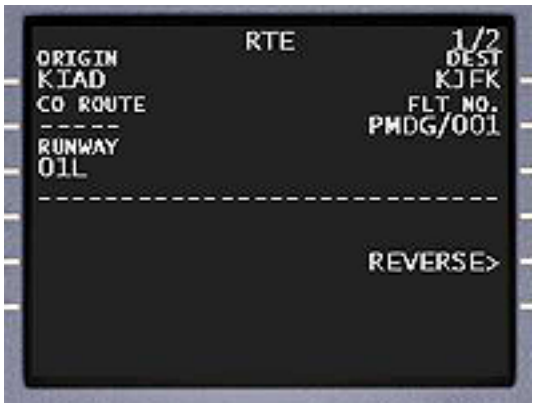
FLT NO: Airline code and flight number. Valid entries are any alpha numeric combination not including + or -. The flight number will automatically be displayed on the PROGRESS page as well, and may be changed but not deleted.

REVERSE: (not always displayed) the REVERSE cue allows you to load a saved flightplan between to points, and to reverse the plan in order to effect a return flight, for example.

ACTIVATE: Once a valid origin/destination have been added to the RTE page and a flight plan has been entered, the FMC/CDU will display the ACTIVATE> prompt at the 6L LSK.

Note: Once the ACTIVATE prompt is selected, the FMC will activate the flight plan to make it usable. This will also trigger the EXEC key on the FMC/CDU to illuminate, indicating that the EXEC key should be pressed in order to confirm the action!

Programming the Route of Flight: Once the ORIGIN, DEST, and FTL NO. have been entered into the RTE page it will look similar to this:



Notice that the page indication has changed from 1/1 to 1/2 this indicates that a second page is now available and can be accessed using the NEXT PAGE key on the FMC/CDU.

Pressing the NEXT PAGE key will display RTE page 2/2 as follows:

The RTE page 2/2 is where crewmembers manually enter the route of flight. This is accomplished by typing fix names individually into the scratch pad, then uploading them in order to the right LSKs.

The RTE page 2/2 should be viewed as two distinct columns based on their titles: VIA and TO.

The TO column is where individual fixes along the route of flight are entered. The VIA column describes *how to get there.* For example, assume that the route of flight to be used is described as follows:

"*Depart KIAD and fly direct to WOOLY intersection, then follow V214 to the SWANN intersection."*

WOOLY is located approximately 20nm north of KIAD, and V214 is a route that has two distinct turns while crossing a half dozen fixes and VORs before reaching SWANN intersection.

Since KIAD has already been entered as the origin airport, it does not need to be entered again into the route.

Type the first fix name (WOOLY) into the scratch pad, and upload the fix to the 1R LSK.

The FMC/CDU will check the database for the intersection name that you have entered, and if it is found to be unique, it will populate the fix name to the appropriate place on the screen. (Depending upon which LSK you pressed….)

In the case of WOOLY, there are more than one intersections that bear this name. Geographically they are very far apart, but the FMC/CDU will always present them to you for validation before using one in a flight plan!

As such, you will be presented with a screen the looks similar to this:

The FMC/CDU will always sort the fixes so that the fix closest to your position will be listed FIRST in the list. This makes

selection easy, but crewmembers are still responsible for verifying fix locations prior to using them for flight!

To select the desired fix, press the LSK adjacent to the name of the fix you wish to use. (In this case 1L LSK.)

The FMC will then populate the fix name to the RTE page 2/2 as follows:

WOOLY is now displayed under the TO column on the RTE page 2/2. You will note that DIRECT is displayed under the VIA column, as the the FMC/CDU assumes that it should fly DIRECT to any fix entered into the RTE page.

The next fix described in the flight plan is SWANN. When SWANN is entered into the RTE page, the FMC/CDU also assumes that DIRECT is the desired method to reach SWANN after passing WOOLY.

This would not be a correct according to our clearance as the cleared route of flight was to follow V214 from WOOLY to SWANN. (The BAL VOR is located between WOOLY and SWANN, but is not on a direct path between the two, so the route of flight turns slightly at BAL.)

On longer routings, a flight path may turn in many places or cross upwards of 40 navigation fixes before reaching desired fix, so the FMC/CDU allows crewmembers to define the "route to follow" in the VIA column of the RTE page 2/2 in order to prevent the typing of every fix name along a route of flight.

In our example, we wish to follow V214 between WOOLY and SWANN. This, we upload SWANN as the fix following WOOLY, but then take the additional step of adding V214 to the VIA column describing how we should reach SWANN.

Examining the RTE page 2/2, now shows that our programmed flight is: DIRECT WOOLY then V214 to SWANN.

When the entire route of flight is entered, the RTE 2/2 page will look something like this:

Note: KIAD-KJFK is a very short route of flight. On longer routes it is possible to have 5 or 6 pages of navigation information added. Simply use the NEXT PAGE key to reach those pages of information.

Saving a Flight Plan: Once the desired route of flight has been entered it is always a

good idea to save the route of flight for future use.

To save a flight plan, return to the RTE page 1 and notice that the <SAVE prompt is now active at the 5L LSK. (You may need to activate your flight plan first!)

By pressing the <SAVE prompt, your flight plan will be saved in a directory as a text file. The file is saved in the following location:

C:\flightsim\PMDG\FLIGHTPLANS

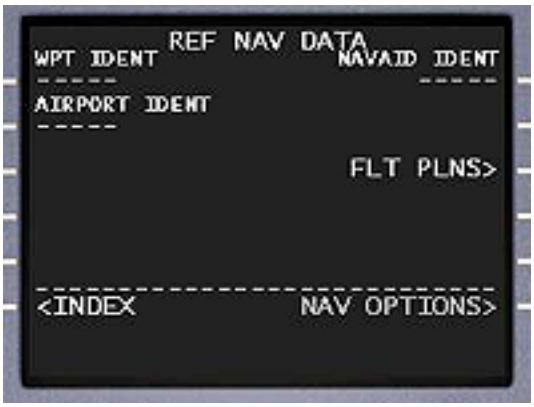
(C:\flightsim is replaced by the root directory of your MSFS installation!)

Your flight plan save will be confirmed by the following message in the scratchpad of the FMC/CDU:

Loading a saved flight plan: Loading saved flight plans is simple to do and very closely mirrors the initialization process used by flight crews around the world to initialize the FMC/CDU prior to flight.

To load a flight plan, press the MENU key to bring up the FMC/CDU main menu as follows:

Select the NAV DATA> prompt by pressing the 1R LSK. This will take you to the NAV DATA screen as follows:



The REF NAV DATA page is used to review information about individual navigation wapoints, navaids and airports from within the naviation database.

Additionally you can review the names of saved flight plans from this location by pressing the FLT PLANS> prompt at the 3R LSK.

This will present you with a list of flightplans that are currently saved in your PMDG/FLIGHTPLANS directory as follows:

Saved flight plans cannot be loaded from this page, as the page is for display purposes only.

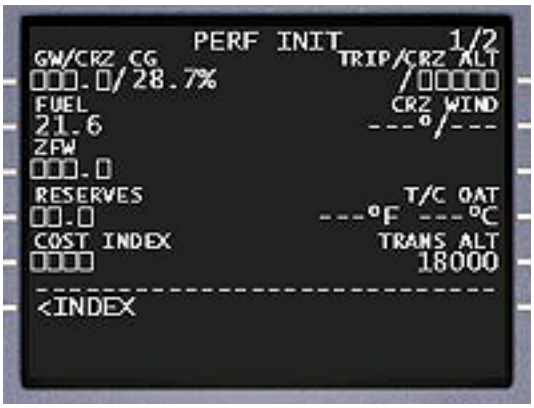
From this page, you can downselect to the scratchpad the name of the flight plan that you wish to load and activate within the FMC/CDU.

To load and activate the flight plan, you simply return to the RTE page, and upselect the flight plan name to the Company Route prompt as follows:

This will load the saved flight plan, and trigger the ACTIVATE> prompt so that crewmembers can confirm the route and EXEC it into active memory.

Note that when the route has been successfully loaded, activated and executed, the RTE page title changes to ACT RTE as displayed above. ACT RTE indicates that the route is ACTIVE.

PERF INIT Page: The performance initialization page allows entry of critical aircraft performance factors needed by the FMS in order to accurately predict aircraft performance. It is easy to determine which items remain to be entered as the FMC places *required entry* boxes in all locations where information is needed.



Note: The title line on this page displays PERF INIT until the initialization is completed, at which point the title changes to ACT PERF INIT to indicate that it is ACTIVE.

The fields displayed on the PERF INIT page are as follows:

GW/CRZ CG: Aircraft Gross Weight in thousands of pounds must be entered at the 1L LSK, followed by the cruise flight CG percent of MAC (Mean Aerodynamic Chord) setting.

Note: *Currently CG functions and %MAC functions are not modeled in the PMDG FMC. These figures are currently static, but will eventually be updated to make them fully functional.*

Aircraft Gross Weight must always equal the aircraft Zero Fuel Weight plus the weight of boarded fuel.

Normally, the gross weight figure that needs to be entered into the GW/CRZ CG line is reported to the crew by the airline load planner who has calculated aircraft mass based on the items loaded and passengers/fuel boarded.

To simulate this process, PMDG has allowed for manual crew entry based on crew flight planning, or crewmembers may alternately press the 1L LSK to automatically populate the current aircraft gross weight to the display.

When the Gross Weight has been confirmed, it is displayed in large font.

FUEL: The FUEL indicator displays the current weight of fuel boarded in thousands of pounds. Total Fuel Quantity is sensed by the Fuel Quantity Indication System (FQIS) and reported to the FMS.

If the FQIS is deactivated or inoperative, prompt boxes will alert the crew to enter fuel quantity manually in line 2L.

ZFW: The aircraft zero fuel weight is displayed in line 3L. Weight is displayed in the thousands of pounds, with an optional decimal point. Prompt boxes alert the crew that the ZFW must be entered manually, however confirmation of GR WT and FUEL fields will automatically update the ZFW field. Again, optionally pressing the 3L LSK will automatically populate this information to the FMC/CDU.

RESERVES: The reserve fuel weight is displayed at line 4L. Prompt boxes alert the crew that a reserve fuel weight in thousands of pounds must be entered. Even if no reserve fuel is to be carried the crew must enter a figure. (0 or greater)

Helpful Hint: The value entered for fuel reserves is used by the FMS to determine when there is no longer sufficient fuel remaining to reach the programmed destination with the desired amount of reserve fuel remaining. Lowering this figure will cause the warning to cease, or lowering current fuel burn rates will also cease the warning.

Occasionally it is possible to trigger the low fuel warning during initial climb out when a combination of factors such as current fuel burn, length of flight, fuel on board and reserve fuel desired create only a small margin of "extra" fuel on the airplane for current conditions. Once the aircraft is stable at cruise flight and current fuel burn is reduced to cruise levels, the warning will normally cease.

Continued INSUFFICIENT FUEL warnings should not be ignored, however as they may be an indication of an impending problem such as excessive headwinds, higher than normal fuel consumption or an undetected fuel leak.

Cost Index: The cost index number is a scale value from 0 to 1000 that helps to determine a level of economy for aircraft performance calculation.

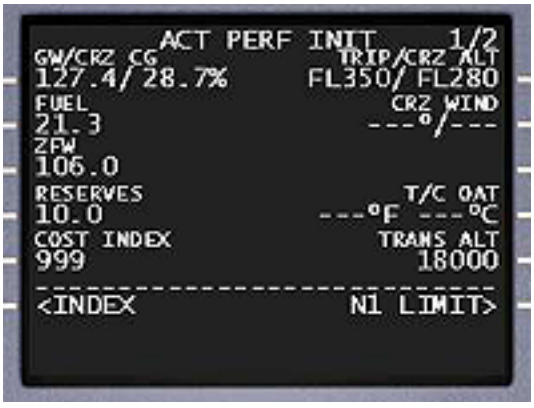
Cost index is calculated as the aircraft operating cost divided by fuel cost. [($/hour aircraft operating cost) / (Fuel Cost in Cents/Pound)] A cost index of 00 will result in the maximum cost economy, with slow climb rates, maximum range cruise and slow descent speeds predicted by the FMC in order to minimize fuel burn. A high cost index will result in higher climb rates, cruise and descent speeds. The cost index is designed to provide a relative index of the cost of aircraft operation vs. time en-route.

Note: *Cost index is not currently functional in this version, but a basic model has completed development. A fully functioning cost index model will be added to the FMC/CDU at a future update.*

TRIP/CRZ ALT: Planned cruise altitude for the flight can be entered in the CRZ ALT section. (Note: Do not exceed the TRIP altitude described here, or you will be planning a cruise altitude that is not economically acceptable for current aircraft conditions and configuration.)

TANS ALT: This entry allows for manual adjustment of the transition altitude for the area of flight.

The completed PERF INIT page follows:



Upon completion of the PERF INIT page, the N1 LIMIT> prompt will be displayed at the 6R LSK.

N1 Limit Page: The N1 Limit page is used to select the thrust performance desired during takeoff and climb.

Available takeoff power derates are listed on the left side of the display while the climb power derates are available on the right side of the display.

Thrust derates are normally used when the aircraft is lighter than maximum gross weight and serve to normalize acceleration forces, takeoff roll and climb rates provided that runway length and climb clearance are not a factor.

For example, if very few passengers are boarded a full thrust takeoff will result in excessive acceleration during takeoff roll and high deck angles due to the over-abundance of thrust based on the light weight of the airplane.

Selecting a lower thrust rating will reduce acceleration forces, deck angle during the climb, and result on lower rates of wear and tear on the engines over time.

When the N1 LIMIT page is brought up during preflight planning, an <ACT> cue is placed in he left-center column of the display in a position to indicate that full takeoff thrust is selected. Pressing either the 2L LSK or 3L LSK will move the <ACT> prompt down to the associated line.

When the takeoff phase of flight is active, the climb thrust cue will show <SEL> to indicate that the thrust mode is not active, but is selected to become active at the thrust rating associated on the right side of the display.

For example, in the image shown above, a TO-1 derate to 22,000lbs of thrust has been selected, with a CLB-2 derated thrust performance

The expected engine N1 percentages for the selected takeoff and climb (given current conditions) are displayed in the upper right corner of the N1 LIMIT page.

After takeoff and climb thrust rates have been selected, the TAKEOFF> prompt at the 6R LSK will complete the preflight process.

TAKEOFF REF Page: The Takeoff page is where final aircraft takeoff configuration is programmed into the FMC/CDU.

The following information is displayed by the TAKEOFF REF page:

FLAPS: The flap setting for takeoff should be entered into the scratch pad and upselected to the 1L LSK.

Thrust Setting: (note: Displayed as 24KN1, 22KN1, 20KN1, etc depending upon thrust setting selected for takeoff.) The expected N1 RPM percentage for takeoff and climb id displayed at the 2L LSK. These entries cannot be modified except by changing the

thrust setting selected on the N1 LIMIT page.

CG: As described earlier, CG and Trim settings described within the FMC are not yet functional within the PMDG FMC. Future updates are planned to bring these capabilities online in a realistic fashion.

V1/Vr/V2: The Next Generation 737 does not automatically populate the FMC with V-Speeds based on crew input to the FMC/CDU. V-Speeds are normally entered manually into the TAKEOFF REF page to control the speed bugs on the Primary Flight Display.

To simplify the process of looking up takeoff performance data, PMDG has automated the process for crewmembers. Simply click on the 1R, 2R and 3R LSKs to automatically populate the correct V1, Vb and V2 speeds to the FMC.

Helpful Hint!: *The Next Generation 737 is a small yet powerful airliner. It is not uncommon to find V1 and Vr speeds that are identical when operating the airplane at low takeoff weights!*

The selected speeds for takeoff are affected by many things, including the runway selected, climb clearances, selected takeoff thrust, aircraft weight and desired flap settings.

If any of these variables are changed after the V-Speeds are selected into the FMC, you will receive a V-SPEEDS DELETED message in the FMC/CDU scratch pad and the speed bugs will be removed from the primary flight display.

This is to prevent the crew from using the incorrect speeds after a change has been made that will affect takeoff performance.

When V-Speeds are correctly selected, the aural warning system on the airplane will automatically call out V1 and V2 speeds. The Pilot Not-Flying should call out the V1 speed at the appropriate time.

The TAKEOFF REF page is normally that last page that is used for preflight and departure. If, when loading this page, the PREFLIGHT COMPLETE descriptor is not seen across the center of the screen, then important data for the FMC/CDU preflight process must still be entered.

Return to the INIT REF page and review all entries to ensure that the missing data is found, entered and a PREFLIGHT COMPLETE message is received on the TAKEOFF REF PAGE.

ARRIVAL / DEPARTURE PROCEDURES

Overview: Many large airports throughout the world have standardized arrival and departure procedures in order to maximize aircraft flow into and out of the airport terminal control area.

These procedures are know as Standard Instrument Departures (SID) and Standard Terminal Arrivals (STAR).

The PMDG FMC is designed to maximize the realism of user experience by including access to many of the SID/STAR procedures used throughout the world.

Note: *We have included a sample of procedures that covers approximately 1300 airports worldwide with runways greater than 5000 feet in length. This procedure database realistically represents approximately 1/3 of all the SID/STAR airports worldwide, and in some cases may not contain all the procedures for any given airport. Additionally because the procedures change continually you may find them to be out of date with currently published procedures.*

We have developed a comprehensive and easy to use programming lexicon to that will allow even novice users to program their own SID/STAR procedures. (see later in this guide!)

PMDG regularly updates the SID/STAR database for the PMDG FMC, and the most current versions of this database will always be available at the PMDG 737 Operators Information Center at [*www.precisionmanuals.com*](http://www.precisionmanuals.com)

Using SID/STARS: Loading a SID/STAR procedures can at first appear complicated to users who do not understand how SID/STAR procedures and TRANSITIONS are used to manage aircraft traffic flow.

The design theory behind SID/STAR procedures is really quite simple: Guide aircraft into and out of the airport terminal space using predicted flight paths in order to keep arrival and departure traffic from conflicting in controlled airspace.

To do this, SIDs are traditionally linked to specific navigation fixes across which departing aircraft fly. For example, a major international airport may have as many as a few dozen pre-defined fixes to across which all departing traffic must cross.

Arriving traffic into an airport will be treated similarly, with aircraft being routed along specific routes to bring them into position from where they can be inserted into the final approach corridor for specific runways.

By publishing these procedures, air traffic control is able to quickly and efficiently assign aircraft to known routes with very little radio work or interaction with the flight crew.

In order to understand how the FMC/CDU manages information related to SID/STARs, it is helpful to imagine the flight linearly.

The first navigation fix that the airplane will use is a runway. Thus, the FMC/CDU will need to know *which* runway it the aircraft will depart from.

The FMC/CDU will also want to know the ROUTE OF FLIGHT that is being used to reach the destination. (Route entry is covered earlier in this chapter)

At the end of the flight, the FMC/CDU will want to know what runway the airplane will land on.

A SID and (sometimes) a TRANSITION is used to show the FMC/CDU how the airplane will get from the departure runway to the ROUTE OF FLIGHT. At the other end of the flight, a TRANSITION (sometimes) and a STAR is used to show the FMC how it will get from the end of the ROUTE OF FLIGHT to the landing runway.

It is important to recognize that not all SID/STARs serve every runway at any specific airport. In fact it is common to find a

specific SID or STAR that only serves a portion of the runways at any given airport and thus it is not unusual to find that selecting certain runways will eliminate some SID/STAR procedures from availability.

Note: *The assignment of a SID/STAR and TRANSITION procedure is normally always handled by ATC, as the procedures are designed to assist ATC traffic flow processes. Crews almost never select and load a SID/STAR without it having been assigned by ATC, but for the purpose of MSFS the use of these procedures is entirely at crew discretion.*

DEP/ARR INDEX Page: The DEP/ARR INDEX page allows for selection of the published arrival and departure procedures at the origin and destination airports.

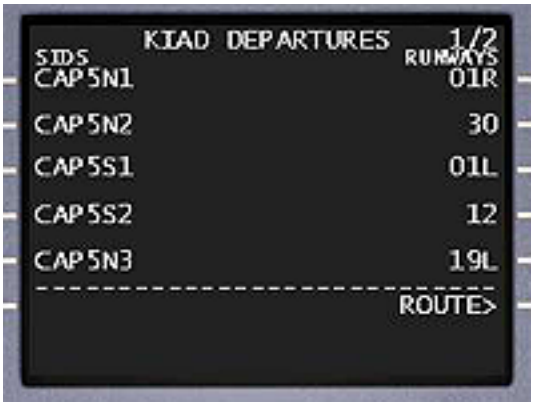
The DEP/ARR INDEX page is accessed by pressing the DEP/ARR key on the FMC/CDU keypad.

The 1L, 3L and 6L keys allow for selection of SID procedures stored in the FMC SID database. Keys 1R through 4R and 6R allow for selection of STAR procedures stored in the FMC STAR database. The center of the display shows the crew entered or COMPANY ROUTE entered arrival and departure ICAO airport codes.

Helpful Note!: The current version of the PMDG FMC does not offer the arrival STAR procedures at the origin airport. If a return to field is necessary, simply change the destination airport on the RTE page 1, then return to the DEP/ARR INDEX page to select the desired STAR procedure.

Departure airport STAR selection will be added at a future date.

DEPARTURES Page: SID selection is made by pressing the <DEP prompt on the DEP/ARR INDEX page. Pressing the <DEP prompt key will display a DEPARTURES page for the selected airport. The DEPARTURES page allows the crew to select the SID and associated runway to be used. A sample DEPARTURES page is shown below:



SIDS: The SIDS are listed on the left side of the display at 1L through 5L. A SID can be selected by pressing the associated LSK. Once a SID is selected, a <SEL> indicator will appear next to the associated SID to indicate that it has been selected by the crew.

When a SID is selected the FMC/CDU will change the list of available runways on the right side of the screen to reflect only those runways that are compatible with the selected SID.

To deselect a SID, simply press the LSK a second time.

Runways: The available departure runways for the selected airport are listed at 1R through 5R. Pressing the associated LSK will illuminate a <SEL> indicator on the selected runway to indicate that it has been selected by the crew.

Selection of a departure runway before selection of a SID cause the FMC to display

only those SID that are compatible with the selected runway.

To deselect a runway, simply press the LSK a second time.

If the DEPARTURES page displayed is for the active route or for the airport of origin, selecting a SID or runway will automatically insert the appropriate fixes into the flight plan and update the runway selection on the RTE page. To alert the crew that these changes have been made, and to allow for verification, the EXEC key will illuminate. Pressing the EXEC key will confirm the selections, but a route discontinuity will be inserted into the route to ensure that the route is verified by the crew prior to being flown.

ARRIVALS Page: STAR selection is made by pressing the appropriate <ARR prompt on the DEP/ARR INDEX page. Pressing the <ARR prompt key will display an ARRIVALS page for the selected airport. The ARRIVALS page allows the crew to select the STAR and associated runway to be used. A sample ARRIVALS page is shown below.

Standard Terminal Arrival Route: The STARs are listed on the left side of the display at 1L through 5L. A STAR can be selected by pressing the associated LSK. Once a STAR is selected, a <SEL> indicator will appear next to the associated STAR to indicate that it has been selected by the crew.

When a STAR is selected the FMC/CDU will change the list of available approaches/runways on the right side of the screen to reflect only those approaches/runways that are compatible with the selected STAR.

To deselect a STAR, simply press the LSK a second time.

Approaches: The available approaches for the selected airport and STAR are listed at 1R through 5R. Pressing the associated LSK will illuminate a <SEL> indicator on the selected approach to indicate that it has been selected by the crew.

When an approach/runway is selected the FMC/CDU will change the list of available STARs on the left side of the screen to reflect only those STARs that are compatible with the selected approach/runway.

To deselect a STAR, simply press the LSK a second time.

If the ARRIVALS page displayed is for the active route or for the airport of destination, selecting a STAR or an approach will automatically insert the appropriate fixes into the flight plan. To alert the crew that these changes have been made, and to allow for verification, the EXEC key will illuminate. Pressing the EXEC key will confirm the selections.

Selection of an ARRIVALS procedure does not need to be accomplished during the pre-flight process, but is included here for balance and clarity. Arrival procedures are normally selected during the initial approach planning phase of the flight.

TRANSITIONS: In some airport environments it is necessary to use a TRANSITION route to move airplanes between the end if a SID and the route of flight, or the end of the route of flight and the beginning of a STAR.

In cases where transitions are defined, the DEP INDEX and ARR INDEX pages will also list the available transitions.

Transitions, like the SID/STARS/RUNWAY/APPROACHES, will cause the FMC to display only those SIDs, STARS or runways with which they are compatible at the time they are selected.

REVIEWING THE ROUTE OF FLIGHT

Overview: After a route is loaded and a departure runway, SID and (if desired) STAR and landing runway are selected, it is always convenient to review the flight plan in detail to ensure that it is accurate.

The Next Generation 737 includes two primary tools to review a flight plan in detail:

- FMC/CDU LEGS pages
- Navigation Display

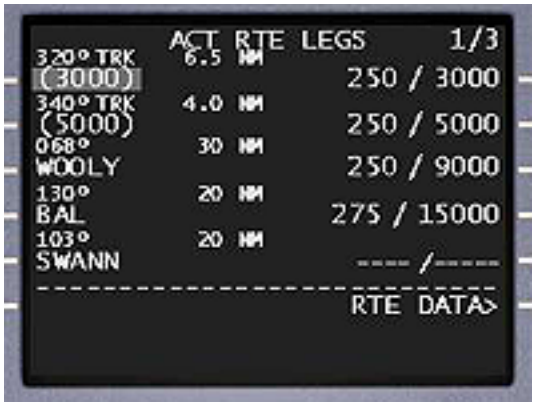
Used in conjunction with one another, the 737 provides a powerful suite of tools to ensure that route entry into the FMC is accurate and matches the clearance received by the crew prior to departure.

RTE LEGS Page: The RTE LEGS page is accessed by pressing the LEGS key on the FMC/CDU.

The RTE LEGS page is similar to the RTE pages in that it displays the route of flight as entered into the FMC/CDU.

The RTE LEGS pages vary, however in that they do not display airway (jet route or victor airway) information, and instead will display for the crew every single fix along a route of flight, no matter how long or how many fixes may exist along an airway.

The RTE LEGS pages also provides valuable navigation information such as distance to fix, distance between fixes as well as planned altitude and speed information.



Information displayed on the RTE LEGS page includes:

FIX NAME: The name of each fix along the route of flight is displayed in the left-most column of the RTE LEGS page. Entries that will be seen in this column include any VOR, NDB, Navaid, waypoint or other geographic fix which is defined within the navdata database.

Additionally, conditional waypoints such as altitudes or locations will be displayed here contained in parenthetics.

Above each fix name, the Desired Track that connects each fix to the next is described in small text.

For example, after crossing WOOLY, the desired track to BAL is 130 degrees. This is the ground track that the airplane should fly when transiting between these two fixes.

Leg Distance Information: The center of the RTE LEGS display provides leg distance information for each leg of the flight plan. Once again, the distance displayed at 1L is the distance from the current aircraft position to the first navigation fix in the flight plan. All other distance indications represent the distance between the previous and next legs of the flight plan.

Speed/Altitude Predictions or Constraints: When the FMC flight plan is fully initialized, the FMC will calculate a set of predicted altitude and speed values for each leg of the flight plan. These predictions appear in small font in lines 1R through 5R. The FMS will provide these predicted altitude and speed values for each navigation fix unless the crew manually enters constraint values into the flight plan.

Constraint (or desired) values may need to be entered by the crew in order to adhere to

published approach procedures or ATC clearances. Constraint values are entered by typing them manually into the scratchpad, then up-selecting them to the desired flight plan leg.

Altitude Constraints: The use of altitude constraints allows the crew to enter either ATC assigned waypoint/altitude constraints, or to program waypoint/constraints assigned by published approach procedures. Altitude constraints are entered by direct entry into the scratchpad, the up-selecting them to the desired line of the flight plan.

The available altitude constraints are as follows:

- AT constraints.
- AT OR ABOVE constraints.
- AT OR BELOW constraints.

AT constraints are used to indicate that the airplane must be at a specific altitude when crossing the associated fix. Entry of AT constraints can be in feet or flight level. (e.g. 18000 or FL180) AT constraints are simply entered into the scratchpad and up-selected to the desired navigation fix LSK.

Note: *The following text describes AT OR ABOVE and AT OR BELOW constraints that are not currently modeled in this version of the FMC. These types of constraints are being developed for the PMDG FMC and will be made available in a future update to the airplane and FMC. They are described here for completeness.*

AT OR ABOVE constraints are used to indicate that the airplane should cross the associated fix at a specific altitude, but may also cross at a higher altitude if the FMS calculates that it is more efficient to do so given the current flight disposition. The AT OR ABOVE altitude constraint can be entered in feet or flight level. (e.g. 18000 or FL180) AT OR ABOVE constraints are entered into the scratchpad in the format XXXXXA or FLXXXA and up-selected to the desired navigation fix LSK.

AT OR BELOW constraints are used to indicate that the airplane should cross the associated fix at a specific altitude, but my also cross at a lower altitude if the FMS calculates that it is more efficient to do so given the current flight disposition. The AT OR BELOW altitude constraint can be entered in feet or flight level. (e.g. 18000 or FL180) AT OR BELOW constraints are entered into the scratchpad in the format XXXXXB or FLXXXB and up-selected to the desired navigation fix LSK.

Speed Constraints: Speed constraints can be used by the crew to comply with ATC assigned speed constraints directly associated with a particular navigation fix. E.g. "Cross HFD at 250 knots."

Speed constraints must always be entered in association with an altitude constraint, and are entered numeric format from 100 to 400 knots Calibrated Air Speed, followed by the '/' indicator which separates the speed constraint from the altitude constraint. (e.g. 'XXX/FL180A')

ABOVE and BELOW modifiers are not possible for airspeed constraints.

According to the sample page shown, the flight plan calls for crossing WOOLY at 250 knots at 9000 feet, then accelerating to 275 knots while crossing BAL at 15000 feet.

Speed information entered into the RTE LEGS page will affect VNAV operation, and altitude information will serve to feed the FMC with vertical planning information even though it is still the crew's responsibility to manage the altitude assignment and altitude change assignments from ATC.

Helpful Hint! When updating the speed and/or altitude constraints, the following formats are usable:

/FL180 (updates altitude only)
/18000 (updates altitude only)
310/FL180 (updates speed and altitude)
310/18000 (updates speed and altitude)
310/ (updates speed only)

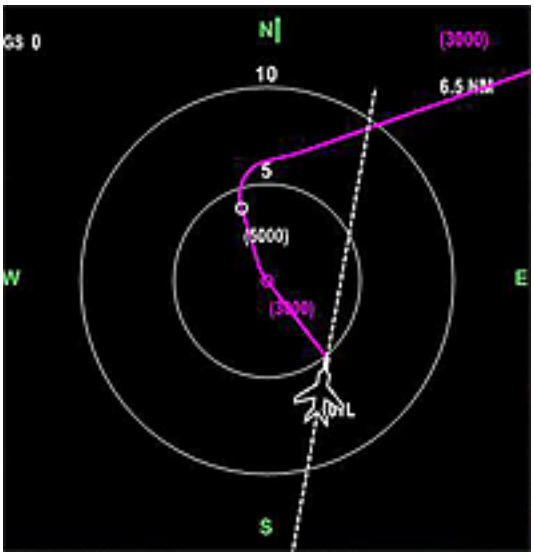
The RTE LEGS page and the ND:
Coupled with the navigation display, the RTE LEGS page becomes a powerful tool that can be used to review the entire route of flight that has been entered into the FMC/CDU.

When the Navigation Display is placed PLN mode, (rotate the selector to PLN on the EFIS MCP) a <CTR> cue will appear in the center column of the RTE LEGS page. The <CTR> cue identifies the fix that is currently used to "center" the navigation display's Flight Plan Display.

The <CTR> indicator can be cycled through all points of the flight plan in order to display portions which may not be visible using the standard range display settings of the ND.

To cycle the <CTR> cue forward, simply press the STEP> prompt that is displayed at the 6R LSK.

With each successive press of the STEP> prompt, the Navigation Display will move further along the flight plan with the center of the display being focused on the fix that is currently identified by the <CTR> cue in the RTE LEGS page.



The fix that is currently the <CTR> cue in the FMC/CDU will be highlighted in white on the navigation display, and will be located at the center of the ND PLAN MODE display.

The navigation display ND PLAN MODE display is always oriented in a north-is-up mode, and can be modified using the EFIS MCP keys to display VOR stations, airports and nav fixes.

FIXES AND CUSTOM WAYPOINTS IN THE FMC

Overview: The FMC/CDU is a highly sophisticated navigation tool that can be used to navigate the airplane to almost any point in three-dimensional space. The database contains tens of thousands of pre-defined navigation fixes that describe the location of airports, approach fixes or reference points in the database.

As a tool, the FMC would be slightly limited if it were not possible for crewmembers to define their own navigation waypoints from within the database when needed.

The FMC is capable of navigating the aircraft to any point in space that can be defined using geographic reference, or reference to a fix already included in the FMS database.

This provides endless opportunity for crews to define points in space that can be used for navigation.

For example, when given ATC instructions to *"cross 15 miles west of XYZ at and maintain seven-thousand"* a fix can be described in the FMC/CDU in order to facilitate compliance with the instructions.

Additionally, the crew can define waypoints simply for their convenience, or for improved accuracy of navigation along extended routes.

FMC Database Waypoints: Waypoints are entered into the left side of the RTE LEGS page individually via the scratchpad. Navigation identifiers/Fixes can be represent the following:

- Airport
- Waypoint
- NDB
- VOR
- VOR/DME
- VORTAC
- DME/TACAN
- Runway
- Final approach fixes

Navigation fixes can be entered into the RTE LEGS page in a number of formats. In most cases, crew embers will navigate using existing navigation fixes such as published waypoints and VORs. These types of navigation fixes can be entered directly into the RTE LEGS page by name, and will be called from the stored FMC navigation database.

FMC Custom Waypoints: In some cases, however, it becomes necessary for crewmembers to provide unique navigation fixes or waypoints to the FMC in order to satisfy the changing ATC requirements, or in order to clearly define an unusual published approach for the FMS. In such cases, it is possible for the crew to define navigation waypoints in the FMC using position and altitude data relative to existing waypoint entries.

Currently, the PMDG FMC is capable of accepting custom waypoint entry in the following formats:

- Place Bearing Distance waypoints (PBDs)
- Bearing / Bearing waypoints (BBs)
- Along Track waypoints (ATWs)
- Latitude Longitude Waypoints (LLWs)

The process for entering these three types of waypoints is described below.

Place Bearing/Distance Waypoints: PBD waypoints can be entered into the left fields of the LEGS page by entering the fix description into the scratchpad and up-selecting to the desired line.

PBD waypoints describe a geographic point that is at a specific bearing and a specific distance from a navigation fix that is already defined in the FMC navigation database.

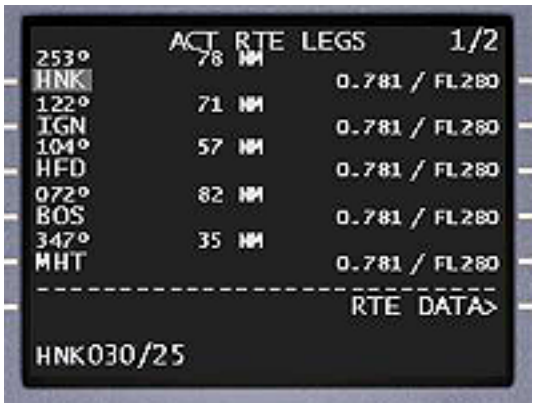
For example, a PBD waypoint can be described as being on a bearing of 180 degrees and 50 miles from the XYZ VOR.

PBD waypoints can be defined from any point in the navigation database.

The proper format for entering a PBD waypoint into the scratchpad is as follows:

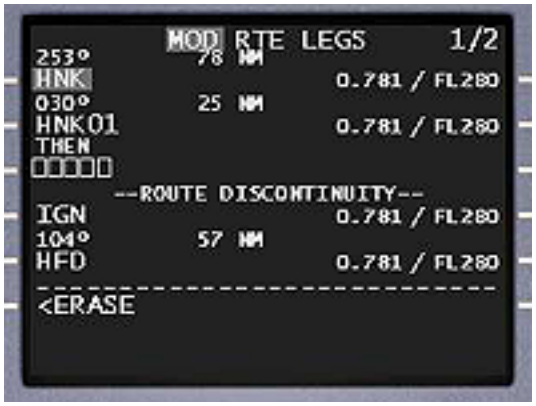
PPPPPBBB/DDD

Where PPPPP is the existing navigation waypoint (1 to 5 alphanumeric characters), BBB.B is the bearing and DDD.D is the distance. The decimal place is considered to be optional for both bearing and distance.



PBD bearing entries from 0 to 360 degrees and distance entries from 0 to 999 miles are valid
Once entered, a PBD is displayed in the route as PPPSS, where PPP represents the first three characters of the navigation fix and SS represents an FMC assigned code number.

In the example above, the fix will be displayed as HNK01, and the FMC/CDU will insert a route disconnect that needs to be resolved and EXECUTED by the crew.

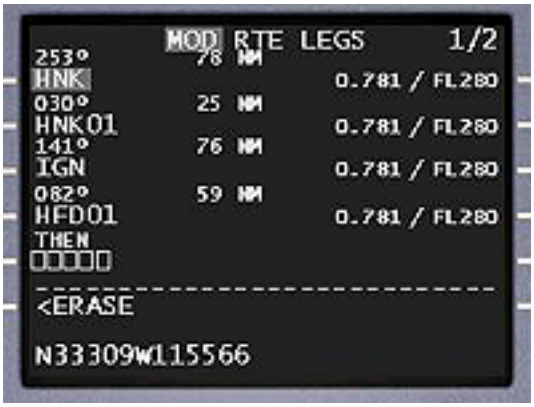


Latitude/Longitude Waypoints:
Latitude/Longitude waypoints are pilot entered waypoints defined by a specific geographic reference in a latitude/longitude format.

The proper format for entering a Latitude/Longitude waypoint into the scratchpad is as follows:

NXXXXX/EXXXXXX
SXXXXX/WXXXXXX

For example, entry for a latitude/longitude waypoint at the geographic location N33º 30.9' W115º 56.6' would be entered as follows:



The entry is then up-selected to the desired line in the RTE LEGS display, where it will be condensed for display in the route, as shown below. The expanded entry can be redisplayed on the scratchpad by pressing the associated LSK.

Place Bearing/Place Bearing Waypoints:
PB/PB waypoints are fixes defined by the intersection of courses from two waypoints. For this reason, PB/PB waypoints are also described as Course Intersection Waypoints. The PB/PB waypoint garners it's name from the fact that the waypoint is being defined at a point which is one bearing from one place and one bearing from another.

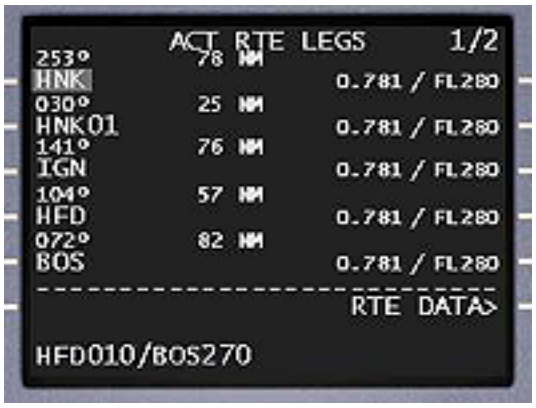
For example, the geographic location where a course of 010 from one navaid intersects a course of 270 from a second navaid is a PB/PB waypoint.

PB/PB waypoints are useful when a navigation fix is defined by the intersection of two courses, or when called upon to navigate a specific radial from one navaid until intercepting a specific radial of a second navaid.

The proper format for entering a PB/PB waypoint into the scratchpad is as follows:

XXXXXBBB/YYYYYBBB

XXXXX and YYYYY represent the existing navigation fixes which are being used to describe the PB/PB waypoint. BBB.B represents the bearing from each existing fix. The decimal point is optional in the bearing entries.



Once entered into the scratchpad, the PB/PB waypoint can be up-selected into the route by pressing desired LSK. The PB/PB waypoint is described in the route by the format XXXSS, where XXX represents the first three letters of the first waypoint's name, and SS is an FMC assigned sequence number.

In the example above, HFD01

PB/PB waypoints can be defined from any fix within the navaid database.

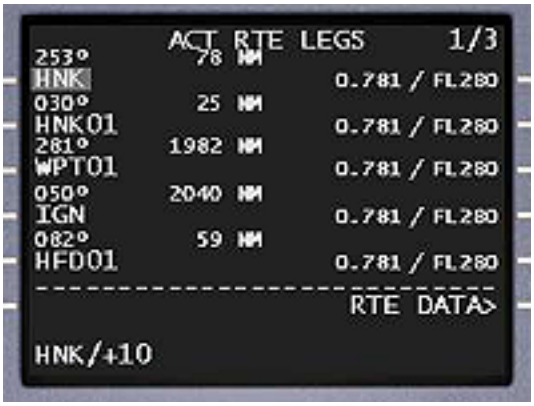
Along Track Waypoints: Along track waypoints are commonly used to mark a descent or climb restriction that is issued by ATC in reference to a navigation fix that exists along the route of flight.

Along Track Waypoints are the simplest of the custom waypoints, because they are entered exactly as issued by ATC.

For example, if ATC were to issue the following climb restriction, "best rate of climb until ten miles beyond HNK" the crew simply enters the restriction into the FMC as an along track fix by using the following format:

FFF/#DD

(Note: The # above should be replaced with either a + or a – sign. + signifies beyond the waypoint while a – signifies before the waypoint.)

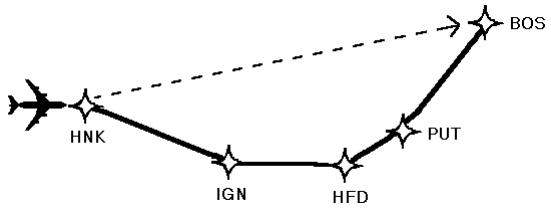


FMC FLIGHT PLAN MODIFICATION

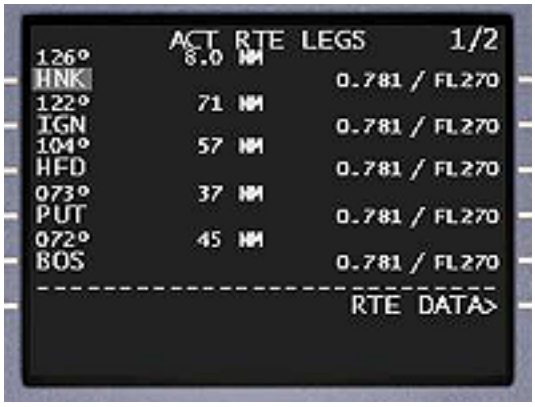
Overview: During the course of a flight it often becomes necessary to adjust a flight plan in the FMC in order to keep it consistent with ATC clearances, shortened routings or route deviations. Using the appropriate FMC function entry to modify a flight plan greatly reduces crew workload when route of flight changes are necessary.

Direct-To: Direct-To flight plan entries instruct the FMC to fly a course direct to a particular fix. The fix may be part of the active flight plan, active modified flight path, or it may be off the intended path of flight.

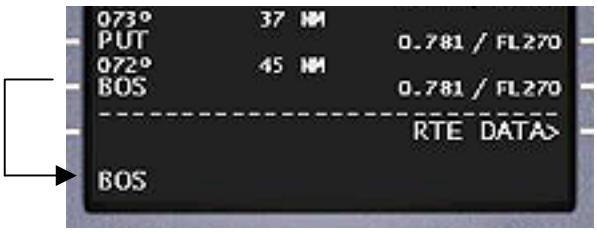
Direct-To routings are often used when ATC issues a shortcut for the route of flight as shown below:



Direct-To routings are most easily accomplished by pressing the LEGS key on the FMC/CDU, and using the ACT RTE LEGS pages.



The simplest way to perform a DIRECT-TO change is to downselect or type the desired fix into the scratchpad:



Then simply upselect the desired fix to the 1L LSK. This will cause the modified route to be displayed on the Navigation Display as a dashed white line, and will illuminate the EXEC key on the FMC/CDU to indicate that the route of flight change must be EXECUTED in order to take effect.

During the modification there are some important changes to notice on the LEGS page of the FMC.

First, when the desired fix is uploaded to the 1L position, the FMC recognizes that a modification has been made to the route. As such, the TITLE LINE of the page changes to MOD RTE LEGS to indicate that the route has been modified, but is not yet active because it has not been EXECUTED.

Additionally, the FMC will offer an ABEAM PTS> prompt at the 5R LSK and an INTERCEPT CRS at the 6R LSK.

To intercept a specific inbound course to a fix, ("Interecept the course 080 TO BOS," for example.) the crewmember simply needs to enter the desired course TO the fix at the 6R LSK.

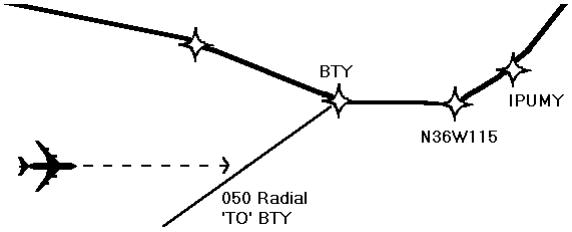
This will cause the FMS to calculate and fly an heading to intercept the inbound radial specified in the INTC CRS prompt.

Pressing the EXEC key will confirm the change, or pressing <ERASE will cancel the Direct-To selection. Once the <EXEC key has been pressed, the FMS will be updated to fly Direct-To the desired fix.

Intercept Course: An intercept course is similar to the Direct-To operation. An intercept course instructs the FMC to intercept a particular course that should be followed TO a specified fix. (It is always helpful to keep in mind that for purposes of the FMC, it must always intercept a course TO a fix.)

Intercept Course entries are useful for complying with SID and STAR transitions, or for complying with an ATC instruction such as, "fly heading 090 until intercepting the 230 degree radial of BTY Fly that radial to BTY then the remainder of route as filed."

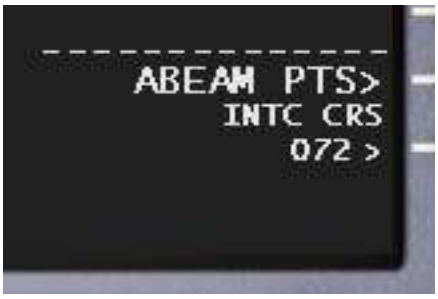
Any time ATC or published route procedures call for the crew to intercept a specific course or heading to/from a navigation fix, the Intercept Course entry can solve the navigation problem via the FMC.



An Intercept Course entry is performed on the LEGS page. Enter the navigation fix that is desired into the scratch pad, the upselect the fix to the 1L LSK. This in effect tells the FMC/CDU that you are planning to cross that fix as the next point along your flight path.

If you were to press the EXEC key at this time, the FMS will provide you with a routing directly from your present position to the fix displayed at 1L. (This would be a Direct-To entry!)

The clearance provided requires that a specific radial be tracked toward the fix, however so an additional step is required.



6R will show the current course to the desired waypoint. If a different intercept course is desired, it should be entered into the scratchpad, then up-selected to 6R by pressing the 6R key. This will instruct the FMS to intercept the desired course to the fix. The FMS will compute a great circle course between the current airplane location and the closest point of intercept to the desired course, and display that course on the ND as a dashed white line.

Pressing the EXEC key will confirm the change, or pressing <ERASE will cancel the Intercept Course selection. Once the <EXEC key has been pressed, the FMS and flight plan will be updated.

If the crew wishes to fly a particular heading until intercept, this can be accomplished by selecting that heading in the MCP heading selector window.

If LNAV is armed, LNAV will engage and begin tracking the inbound course when the aircraft approaches the intercept course entered into 6R.

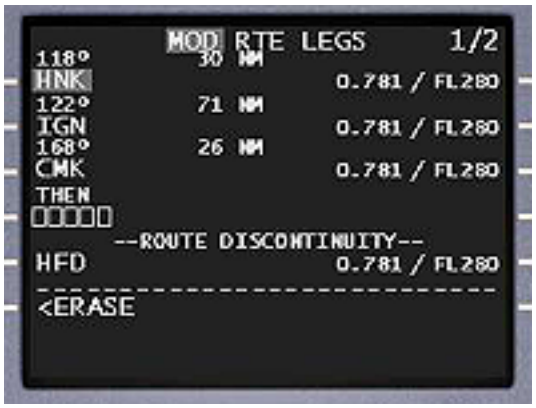
Inserting A Navigation Fix: During flight it may become necessary to insert a new navigation fix into the flight plan in order to comply with ATC procedures or instructions.

This task is also accomplished using the LEGS page in the FMC/CDU.

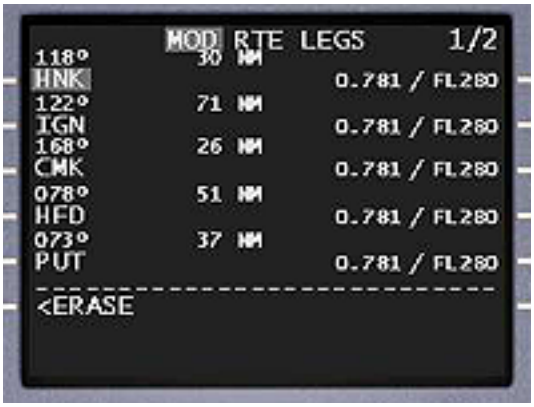
Enter the name of the fix directly into the scratchpad.

The fix identifier is then up selected into the ACT RTE LEGS page at the position that is desired along the route of flight.

When up-selecting a navigation fix to an existing flight plan, the FMC will add the new fix to the line selected, and move all following navigation fixes down in the sequence. When inserting fixes into a flight plan, the FMC will display a set of prompt boxes in the line immediately following the new fix, along with the message ROUTE DISCONTINUITY. This alerts the crew that they must confirm for the FMC which navigation fix will follow the newly added fix.



To confirm the continuation of the route, the waypoint identifier for the next fix in the desired route sequence should be down-selected to the scratchpad by pressing the associated LSK. This fix identifier can then be up-selected to the line containing the disconnect prompt boxes. The FMC will then re-sort the flight plan to allow the updated routing.



Pressing the EXEC key will confirm the change, or pressing <ERASE will cancel the Intercept Course selection. Once the <EXEC key has been pressed, the FMS and flight plan will be updated.

Deleting a Navigation Fix: Navigation fixes can be deleted from the active flight plan using similar methods.

From the RTE LEGS page, use the NEXT PAGE/PREV PAGE keys until the desired fix is displayed on the page, then press the DEL key on the FMC/MCDU keypad.

The DELETE prompt will appear in the scratchpad, indicating that the next LSK pressed will cause deletion of that associated flight plan navigation fix.

The desired fix can then be deleted by pressing the associated LSK. This will cause the FMC produce a modification to the active route that eliminates that fix from the flight plan.

When deleting fixes from a flight plan, the FMC will display a ROUTE DISCONTINUITY that needs to be connected using the same technique described above.

FMC TAKEOFF PROCEDURES

Overview: The FMC provides a number of functions to assist with the takeoff planning process. Specifically, the FMC is capable of taking desired performance input from the crew and calculating engine thrust limits, engine takeoff thrust derates and autothrottle management.

These features are used as part of the normal pre-takeoff process, and are described below.

The FMC/CDU carries a tremendous amount of data regarding engine performance under greatly varied conditions. This data, combined with sensor input from the Air Data Computers and the crew is used to automatically manage the engines in such a manner that engine limitations are never exceeded. Put another way, the FMS will allow the crew to operate the engines to the peak of power or efficiency without undue concern for engine damage by over temperature conditions.

N1 LIM Page: The N1 LIMIT page provides the crew with the ability to manually select the thrust modes to be used by the FMS to provide thrust limits and thrust commands to the autothrottle servos.

The N1 LIMIT page can be displayed by pressing the N1 LIMIT key on the FMC/CDU, or by selecting the appropriate LSK when the <N1 LIMIT prompt is displayed at the INIT/REF INDEX page or PERF INIT page during pre-flight. A sample N1 LIMIT page is shown below:

The N1 LIMIT page displays three takeoff thrust limit options at lines 2L through 4L. Lines 2R through 4R display climb thrust limit options. Additional information to help the crew obtain a clear picture of expected engine performance is also available from this page.

The N1 LIMIT page contains the following items of interest to the crew:

SEL/OAT: Selected Outside Air Temperature and sensed Outside Air Temperature are displayed at the 1L LSK.

Selected Outside Assumed Air Temperature: The 1L key provides the crew with the ability to enter an assumed air temperature (SEL). Valid entries are one or two digit entries from 0 to 99. This field cannot be changed once the aircraft exceeds sixty five knots, or after autothrottle engagement. The field will be removed once the aircraft becomes airborne.

The field can be removed by using the DELETE key on the FMC/CDU.

Helpful Hint!: The SEL entry is used to enter a temperature that is different from that being detected by the air data computer. For example, if a temperature difference is expected between the current aircraft location on the airfield and the temperature that is expected at the runway threshold, the expected threshold temperature can be added so as to ensure that an accurate estimate of thrust ratings can be computed by the FMS.

Outside Air Temperature: The Air Data Computer measured OAT is displayed in the center of row 1.

Thrust Limit Mode: The currently selected thrust limit mode is displayed in small font in the header line for 1R. (displays 24KN1 in this image) This header will change to match the current thrust rating that has been selected for the engines. In addition, the

N1% limit for this thrust mode is displayed in large font at 1R. Note that if CLB-1 or CLB-2 has been selected for the climb, the N1% displayed at 1R will continue to by the full thrust rating for the engines in the given conditions.

Following are the available thrust limit modes:

TO	24K
TO 1	22K DERATE
TO 2	20K DERATE
GA	Go-Around
CON	Continuous
CRZ	Cruise
CLB	Climb
CLB 1	3% N1 derate
CLB 2	6% N1 derate

Takeoff thrust and Takeoff thrust Derates:
Lines 2L through 4L show the available takeoff thrust limit modes which may be selected by the crew. In order, they are:

- TO: Takeoff is the normal full takeoff thrust mode rated at 24,000lbs.

- TO 1: Takeoff 1 is derated to 22,000lbs.
- TO 2: Takeoff 2 is derated to 20,000lbs.

The takeoff thrust limit mode is selected by pressing the associated LSK. When a mode is selected, the <ACT> indicator will move to the associated line to indicate which mode is currently selected. In addition, the takeoff thrust limit mode will be displayed in 1R. Selecting either 24KN1, 22KN1 or 20Kn1 and will override any assumed air temperature figure entered into 1L by the crew.

Climb Thrust and Climb Thrust Derates:
Lines 2R through 4R show the available climb thrust limit modes which may be selected by the crew. In order, they are:

- CLB: Climb is the normal climb thrust mode.

- CLB 1: Climb 1 gives 3% lower N1 and 8% lower climb thrust.

- CLB 2: Climb 2 gives 6% lower N1 and 16% lower climb thrust.

The desired climb thrust limit mode is armed by pressing the associated LSK. When a mode is selected, the <SEL> indicator will move to the associated line to indicate which mode is currently armed.

If a derated takeoff thrust limit was selected, the FMC will automatically suggest an optimal climb thrust derate given current temperature or assumed temperature entries. This mode can be changed by simply selecting a different climb thrust mode.

Notes Regarding Reduced Thrust: In the interest of reduced wear on the engines, reduced thrust should be used whenever practical.

Climb thrust derates are designed to lower the climb angle and are particularly beneficial in the following ways:

- Reduce climb angle increases over-the-nose visibility in congested airspace.
- Reduced climb angle reduces the rate of pitch-over if the aircraft needs to level at a low altitude initially after takeoff.

CLB-1 reduces N1 by approximately 3% while the aircraft is below 10,000 feet and then gradually adjusted thrust upward so that both engines are operating at full thrust by the time the aircraft reaches 15,000 feet.

CLB-2 reduces N1 by approximately 6% while the aircraft is below 5,000 feet and then gradually adjusts thrust upward so that both engines are operating at full thrust by the time the aircraft reaches 15000 feet.

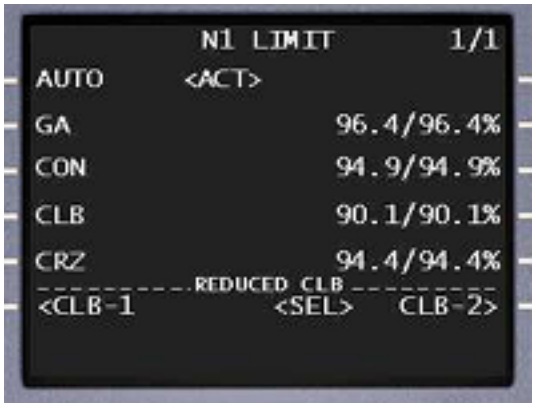
Since both reduced thrust climb modes operate only below 15,000 feet, the CLB page should be used to monitor engine thrust when below 15,000' when climb thrust is reduced. Once over 15,000 feet, use the N1 LIMIT page for monitoring engine thrust.

Helful Hint!: Use the CLB and N1 LIMIT pages to determine what power settings should be used when hand flying the aircraft or when flying the aircraft with the autothrottles selected off or deferred.

When flying a departure procedure that requires the aircraft be leveled at a low altitude immediately after takeoff, use of CLB-2 is generally a good technique to reduce the sensation of pitch-over that is experienced by passengers when the aircraft is operated at higher power settings.

In Flight Thrust Modes: When airborne, the N1 LIMIT page will not display takeoff or climb thrust modes. These modes will be replaced by the in-flight thrust limit modes. These modes will be displayed in lines 1L through 3L of the THRUST LIM page, and are as follows:

- GO AROUND: Go around thrust limit.
- CONTINUOUS: Continuous maximum allowable thrust limit.
- CLIMB: Full Climb Thrust
- CRUISE: Cruise limit thrust .



To select any of the various thrust limits available, simply press the associated LSK and the FMC/CDU will update the FMS to adjust the available thrust limit. Likewise, the CLB-1 and CLB-2 derated climb thrusts can be selected by pressing the associated LSKs near the bottom of the display.

Go around thrust is a limit mode provided for go around conditions, where high engine thrust settings are required for a short period of time.

Continuous thrust limit mode provides the highest thrust output possible from the engines in continuous operation. This mode is useful in situations involving engine failure while the aircraft is at high gross weights, or at a high cruise altitude. This thrust limit mode will provide the highest thrust output possible without damaging engines.

Cruise thrust limit mode is the normal operating thrust limit mode for normal cruise flight operations.

TAKEOFF REF Page: The TAKEOFF REF page provides information pertaining to takeoff performance and settings. This information includes such settings as flap acceleration height, engine out acceleration height, thrust reduction height, runway slope and wind condition information, runway condition, takeoff speeds, trim and runway position shift information.

Flap Setting: The planned flap setting can be entered at line 1L. If an invalid takeoff flap setting is entered manually at 1L, an error message will be generated. The takeoff flap setting must be correct in order for the FMC to generate the correct takeoff speeds.

Planned Thrust: The thrust selected in the N1 LIMIT page is displayed at line 2L. Additionally, the maximum available N1 speed is displayed in large font.

CG/Trim: Information not usable within MSFS at this time.

Takeoff Speeds: V1, VR and V2 reference speeds are displayed in lines 1R through 3R. The speeds are not automatically populated to the display, but can be brought up by pressing in the 1R, 2R and 3R LSKs

respectively once the preflight is completed and a flaps setting is entered at the 1L LSK.

The crew is responsible for validating the accuracy of these computed takeoff speeds by manually checking them against the manufacturer specified takeoff speeds.

Takeoff speeds can be overridden or manually entered by the flight crew if desired. Valid entries are any three digit number from 100 to 300.

If any changes are made to the takeoff performance initialization, the takeoff speeds will be removed and must be reconfirmed.

FMC CLIMB OPERATIONS

Overview: The FMC provides a number of methods to assist the crew in planning, managing, and effecting a precise and economical climb regime of flight. The FMC accepts climb performance demands from crew member entries, and adjust aircraft performance via the FMS and autothrottle servos.

CLB Page: The climb page allows crew access to current and upcoming climb conditions and climb profile information. The active climb speed mode is always displayed in the CLB page.

The CLB page is accessed by pressing the CLB key on the FMC/CDU. A typical CLB page is shown below:

CRZ ALT: The cruise altitude that has been planned for the flight is displayed at 1L. The current cruise altitude is displayed if one has been selected and CLB is the active mode. If the current altitude is not displayed, 1L will contain prompt boxes which can be replaced by up-selecting the desired cruise altitude from the scratchpad.

TGT SPD: The Airspeed / Mach number displayed at 2L represents that target climb speed/mach number for the climb phase of flight. This is the target climb speed to which the airplane will accelerate if operated under VNAV once the airplane is clear of other, more restrictive speed constraints for flaps or regulated airspace.

SPD REST: The SPD REST field at 3L is a dynamic information field that will change during the course of the climb to show the MOST RESTRICTIVE speed that can be allowed for the climb.

For example, when a FLAPS10 takeoff is planned, 161/FLAPS will be displayed at 3L as the speed and reason for the restrictive speed limitation.

As the flaps are retracted, the 161/FLAPS will change to 171/FLAPS, etc, indicating that as the aircraft is cleaned up for high speed flight it is possible to increase the speed constraint for the climb.

When the aircraft is clean and able to accelerate for climb, the 3L LSK prompt will display the speed restriction as defined below the local transition altitude.

For example, in the US, if an 10,000 foot transition altitude is used, the 3L LSK will display 250/10000.

Once clear of all restrictions, the restrictions at 3L will be deleted and the aircraft will accelerate to TGT SPD (if operated under VNAV.)

When not operated under VNAV, the crew may use this page to determine the current restrictive speed or planned climb speed.

Maximum Climb Rate: The speed and climb gradient that will yield the maximum climb rate given the current aircraft configuration can be attained by pressing the 5L LSK at the <MAX RATE prompt.

Maximum Climb Angle: The speed and climb gradient that will yield the maximum climb angle given the current aircraft configuration can be attained by pressing the 6L LSK at the <MAX ANGLE prompt.

In the event of an engine failure, the MAX ANGLE speed will be replaced with the engine out maximum altitude figure for the current aircraft configuration. (Engine Out

Data Not currently modeled in the PMDG FMC. In the event of an engine failure use the maximum angle of climb prompt.)

Engine Out Climb Mode: (NOT MODELED) Selecting the ENG OUT> prompt at 5R will result in FMC calculation of engine-out speed schedules, performance predictions and guidance. When selected, the FMC will detect which engines are not operating, and adjust performance predictions and guidance accordingly. If the FMC detects that all engines are operating, then performance predictions for a single outboard engine failure will be used.

TO T/C: To Top-of-Climb describes the estimated distance and time of crossing (in UTC) for the Top of Climb based upon the final cruise altitude as programmed into the FMC/CDU.

FMC Climb Profile Logic: The FMC is programmed for a default climb logic to select a 250 knots climb to 10,000 feet, followed by an economy climb to cruise altitude. The crew may modify this climb profile via the RTE LEGS page.

In the event that the FMC cannot comply with the next altitude restriction programmed into the RTE LEGS page, (either due to rate of climb or speed related concerns) the prompt UNABLE NEXT ALT will be displayed.

Helpful Hint!: If you receive the UNABLE NEXT ALT warning from the FMC, it is almost certainly a result of trying to reach a higher altitude than is possible given the current climb gradient. Often times adjusting the speed or planned altitude to cross a specific waypoint will cause the warning to cease.

FMC CRUISE OPERATIONS

Overview: Use of the FMC for cruise flight operations greatly reduces en-route pilot workload, and simplifies the process of providing the greatest level of operating economy possible with the aircraft. The Cruise capabilities of the FMC include fuel management, engine out operations, VNAV cruise modes and altitude step climb operations.

CRZ Page: The CRZ page provides the crew with access to current and upcoming cruise profile information. Information displayed in the CRZ page includes the current commanded cruise altitude, cruise speed, N1% target settings, step climb size, next step to fix, next waypoint ETA and fuel, optimum and maximum cruise altitude and engine out cruise setting information.

A sample CRZ page is shown below:

Information contained in the CRZ page includes:

CRZ ALT: Line 1L shows the currently selected cruise altitude. This information will always be displayed unless a descent mode is activated. Prompt boxes in the CRZ ALT line indicate that crew entry of cruise altitude is required. The displayed cruise altitude is the altitude that was entered into the flightplan as described earlier.

The selected cruise altitude can be modified either by direct entry into the CRZ page, or by selecting a new altitude using the MCP altitude knob.

If the MCP altitude is set to an altitude that is higher than the current cruise altitude, the cruise altitude will be updated to the new altitude.

If the MCP altitude is set to an altitude that is lower than the current cruise altitude and the aircraft is more than 50 miles from the top-of-descent, the cruise altitude will be updated to the new altitude and a descent commenced.

If the MCP altitude is set to an altitude that is lower than the current cruise altitude and the aircraft is within 50 miles of the top-of-descent, an early descent will be initiated at a rate of 1000 fpm until the normal descent path is intercepted.

TGT SPD: The target speed displayed at the 2L LSK becomes active when the aircraft levels off at cruise altitude. The target speed will then be highlighted to indicate that it is active.

TURB N1% (Not modeled) The N1% that should be used in the event of entry into turbulent air is displayed at the 3L LSK. This is the thrust setting that will provide the optimal turbulent air penetration speed given the current altitude and conditions.

FUEL AT: The 4L LSK displays the FMS calculated planned landing fuel figure at the destination. The number may vary slightly during climb and initial cruise while average fuel burn figures are higher than cruise fuel burn.

This prompt can be highly useful when selecting a higher/lower than planned cruising altitude or modifying the route to destination, or the destination itself. Before EXECUTING the route modification, return the the CRZ page and verify the planned fuel at landing given the new route/destination/altitudes.

OPT/MAX: (Not modeled) In the center of the display, the Optimum and Maximum altitudes for the current aircraft weight and flight conditions are displayed. These values can be used to ensure proper altitudes are being selected during the cruise portion of flight.

Note: *To be added along with active cost index calculation and STEP TO functionality in a future PMDG update.*

TO T/D: To Top-of-Descent describes the estimated distance and time of crossing (in UTC) for the Top of Descent.

ENG OUT: (Not Currently Modeled.)In the event of an engine failure in flight, selecting the ENG OUT> prompt at 5R will instruct the FMC to provide engine-out speed schedules, performance predictions and flight guidance.

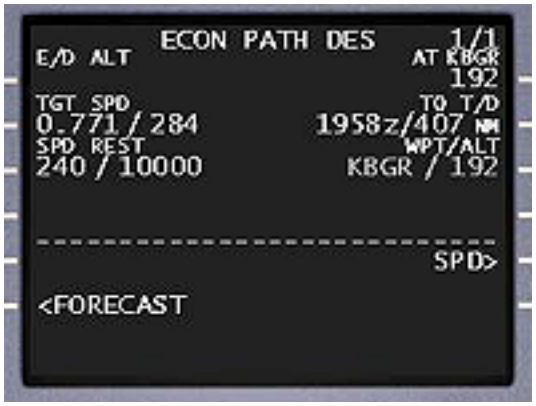
In the event that the aircraft is above the maximum engine out altitude at the time of the engine failure, the cruise altitude will automatically be lowered to the engine out maximum altitude.

FMC DESCENT OPERATIONS

Overview: The FMC descent capabilities provide for descent planning and execution. A planned descent can only exist when a lateral route containing at least one descent constraint is active in the RTE LEGS page.

The descent planning features of the FMC allow the crew to set speed transitions, descent path restrictions, and waypoint dependent speed and altitude constraints.

DES Page: The descent page provides the crew with access to descent planning and information. The DES page is selected by pressing the DES key on the FMC/MCDU keypad. The NEXT PAGE/PREV PAGE keys may need to be used if the aircraft is still at cruise altitude. A sample DES page is displayed below:



The following information is provided on the DES page:

E/D ALT: The End of Descent Altitude information displayed in 1L describes the altitude and waypoint at which the descent is planned to end. When no SID/TRANSITION or APPROACH fixes are entered, this area will be blank.

AT: Line 1R contains the descent constraint waypoint as defined in the RTE LEGS page of the flight plan. The header line contains 'AT' followed by the navigation fix identifier to which the descent constraint is assigned. The constraint is displayed in the DES page exactly as it appears in the RTE LEGS page. The descent constraint cannot be updated or changed from the DES page, but it may be deleted. Deleting the constraint will remove it from the lateral route.

TGT SPD: Line 2L contains the descent speed mode information.. The descent speed is displayed in large font, in the Mach/Airspeed. Information on this line cann be updated manually if desired.

SPD REST: Line 3L provides the crew with the ability to enter an altitude dependent speed restriction. The line contains transition speed, followed by the transition altitude in a SSS/AAAAA format. The altitude entry must be an altitude below the cruise altitude, but above the End of Descent altitude.

If operating in VNAV, this speed/altitude constraint pair will be used in planning the deceleration prior to descent below the designated altitude.

TO T/D: To Top-of-Descent describes the estimated distance and time of crossing (in UTC) for the Top of Descent.

WPT/ALT: Not currently modeled.

DES NOW: When the aircraft is not currently descending, but the MCP altitude selector is set below the current altitude and the aircraft is within 50nm of the Top-of-Descent, the DES NOW prompt will be displayed at 6R. The DES NOW> prompt deletes all climb/cruise constraints and commences an early descent. The rate of descent will be approximately 1000 feet per minute until the aircraft intercepts the originally planned vertical descent path which would have commenced at the top-of-descent mark.

Descent Methods: There are two methods that can be used to plan descents in the Next Generation 737. Speed based descents and path based descents.

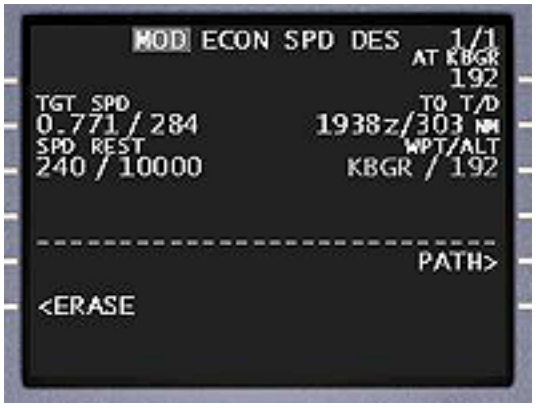
The FMC prefers to calculate a path that will allow for a throttle-idle descent path. Based on current conditions and any wind information entered into the DES FORCAST page, the FMS will calculate a descent path that will allow for the most economical power-idle glide down from cruise flight.

This calculated descent is called a "Descent Path."

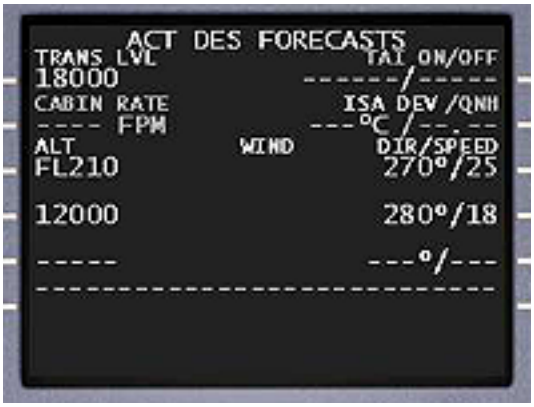
At the top of the previous image, the title line contained the title ECON PATH DES. This indicates that the descent method being used bt the FMC is the descent path profile that will give it the throttles-idle descent path.

A second descent method is also available, depending upon crew preference.

A SPEED based descent will allow the crew to plan a descent at a specific speed, with power and elevator being managed to maintain the desired speed during the descent.



DESCENT FORECASTS Page: The DESCENT FORCASTS page allows the crew to enter and use forecast values for wind, transition level, anti-ice settings and descent wind direction information. A sample DESCENT FORECASTS page is shown below:



The following information is provided on the DESCENT FORECASTS page:

TRANS LVL: The transition level for the destination airport is displayed in 1L. The transition level can be modified by up-selecting from the scratchpad.

CABIN RATE: (Not Modeled) The rate of descent required to adjust the cabin altitude rate of descent in order to minimize the rate of change in cabin pressure.

TAI ON/OFF: Altitude at which anti ice is projected to be necessary. Boeing has disabled this capability as of this writing.

ISA DEV/QNH: Destination airport temperature deviation from Standard Atmoshperic Conditions and airport QNH. This information is used to plan the descent portion that will take place below the Transition Level entered at the 1L LSK.

WIND ALT/ DIR/SPD:
Wind altitude speed and direction entries are made by the crew based upon reported conditions, observed conditions (use the wind indication on the Nav Dissplay!) or forcast conditions in order to assist the FMC in computing the descent profile as defined in the flight plan.

Helpful Hint!: This functionality is operating in the PMDG FMC and is very important for accurate descent planning purposes. If you find that you are continually receiving a DRAG REQUIRED message during descent, it could be that you have not entered wind conditions into the forecast page when a tailwind condition exists.

Conversely, if you find that the descent appears to be shallow or power is needed to maintain the descent path, a headwind could exist along the descent path that was not entered into the Forecast page.

Altitude bands for the winds are entered at the discretion of the crew.

Descent Profile Logic: The default descent profile logic is to effect an economy descent form cruise altitude to the transition altitude. After passing through the transition altitude, 240 knot descent is commanded. The crew may manually override the default descent profile through the use of speed and/or altitude constraints entered into the RTE LEGS page. The descent profile can also be modified using the MCP speed and/or altitude selector knobs. A combination of RTE LEGS entries and MCP selections can be used to adhere to ATC instructions, or to expedite the descent profile as needed.

During the descent, the aircraft will occasionally reach the descent limit speed regime while attempting to maintain the calculated vertical profile. This can occur as a result of headwinds or tailwinds, or wind forecasts not being entered correctly in the DESCENT FORCASTS page. The DRAG REQUIRED prompt is generally a good indication of a tail wind condition or descent overshoot, while the THRUST REQUIRED prompt generally indicates headwinds, or descent undershoot.

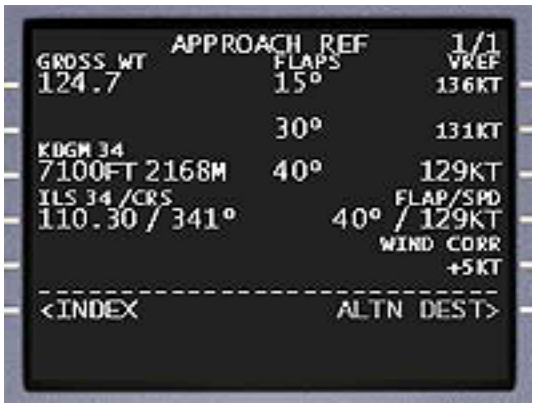
In cases of descent undershoot and overshoot, once the aircraft reaches the limit speeds (upper or lower limits) the vertical guidance function of the FMC will command the aircraft to depart the planned vertical profile while maintaining a descent that most closely follows the planned descent profile.

Adding drag or thrust as required will normally return the aircraft to the planned descent path.

FMC APPROACH PROCEDURES

Overview: The FMC approach initialization pages provide the crew with quick and effective access to the landing flap and speed selection process. The FMC provides the crew with approach speed calculations for weight/speed data and provides reference information for the touchdown.

APPROACH REF Page: The approach page provides the crew with information directly related to the final approach to landing process. A sample APPROACH REF page is shown below:



The following information is provided on the APPROACH REF page:

GROSS WT: Line 1L provides the current airplane gross weight in thousands of pounds unless the figure has been manually adjusted by the crew. Manual adjustment of the GROSS WT figure is accomplished by up-selecting a manually entered figure from the scratchpad. Valid entries are three digits with an optional decimal point. Crew entered GROSS WT values are used for predictive purposes only, and do not affect aircraft computation of actual gross weight.

Runway Length: Line 3L contains runway reference information to assist the crew in planning the touchdown and stopping phase of flight. The header line in 3L will display the ICAO airport identifier, followed by the runway number and L/C/R designator.

Runway length reference information is provided in large font in 3L, and is displayed in both feet and meters.

Helpful Note!: *This information is only displayed after an approach the the destination has been selected in the DEP/ARR menu.*

ILS FREQUENCY/COURSE: To further assist the crew with rapid information management, the instrument approach frequency and final approach course are provided at the 4L LSK after an instrument approach is selected to the destination airport.

FLAPS/VREF: The Vref reference speeds for the FLAPS15, FLAPS30 and FLAPS40 landing flaps settings are provided in lines 1R, 2R and 3R respectively. These Vref values are directly reported from the aircraft performance database, and will change as the GROSS WT figure in 1L changes.

FLAPS/SPEED: After reviewing the information contained in the APPROACH REF page, the crew can select the desired landing flap setting by down-selecting from either 1R , 2R or 3R. This will cause the selected landing flap setting to be automatically populated to the 4R LSK under the FLAP/SPD title. This line serves as a quick reference for the currently selected landing flap setting and approach reference speed.

Additionally, if the crew desires to update the landing flap speed to adjust for windshear or gusts, the flap setting/speed can be upselected from the scratch pad using the format FF/SSS.

FMC FLIGHT REFERENCE AND CREW SUPPORT

Overview: The FMC is capable of providing the crew with information regarding the performance of the aircraft during flight, as well as supporting information which can help the crew to make informed and accurate decisions.

PROGRESS Pages: The progress display occupies two display pages, and can be called up by pressing the PROG key on the FMC/CDU.

The first progress display page is shown below.

FROM / ALT/ATA/FUEL: The first line of the PROGRESS page display contains information related to the last flight plan fix that was over flown.

From left to right, the information displayed includes:

- The name of the fix.
- Aircraft altitude at time of fix crossing. (in thousands)
- Actual Time of Arrival at last fix.
- Fuel on board at the time of fix crossing.

NEXT / DEG / ETA / FUEL: The second line of the PROGRESS page display contains information describing the fix that is currently the active fix in the flight plan.

From left to right, the information displayed includes:

- Direct Ground Track from previous fix to current fix in the flight plan.
- Distance to go to current fix.
- Estimated Time of Arrival at current fix.
- Predicted fuel remaining at the current fix.

The same information for the next fix in the flight plan is contained in line three of the PROGRESS display.

The fourth line in the PROGRESS display includes the destination, distance to go, ETA at destination and estimated fuel remaining at destination.

This line can be used to estimate arrival time at the gate and fuel on board the aircraft any time a route edit has been made.

TO T/D: Line Five of the display includes planning information to display the distance and fuel quantity on board the aircraft when reaching the Top-Of-Decent point for the flight plan. The estimated time of crossing for the TOC is also displayed.

WIND: The current wind conditions as calculated by the FMS is displayed at the 6L LSK. This information can be downlselected to be added to the descent forecast if desired.

The second PROGESS page is reached by using the NEXT PAGE/PREV PAGE keys, and is displayed below:

The PROGRESS 2/2 page contains additional information on the wind, temperature and navigation accuracy of the aircraft.

Line one contains the calculated tailwind/headwind and crosswind component described in knots. This information is a vector breakdown of the wind information contained on the PROGRESS 1/2 page.

Additional information includes:

WIND: Line 2 displays the current wind conditions at the location and altitude as calculated by the FMS.

SAT/ISA DEV The 2R LSK displays the current SAT and it's deviation from ISA conditions.

Line 3 displays both cross track error (XTK ERROR) and vertical track error (VTK ERROR) in nautical miles and feet.

XTK ERROR is displayed in nautical miles with a L and R designator to indicate that the aircraft has drifted left or right of course respectively. Distance values are displayed up to 99.9 nautical miles.

VTK ERROR is displayed in feet, with a + and – sign to indicate deviation above and below planned flight track. Vertical track error is displayed when the aircraft is in the descent phase of flight.